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Some saprobic fungi on *Typha latifolia* and their competitive interactions in leaves

by

Michael J. Schulz

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science

In

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The undersigned certify that they have read, and recommended to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **Some saprobic fungi on *Typha latifolia* and their competitive interactions in leaves** submitted by Michael J. Schulz in partial fulfillment of the requirements for the degree of Master of Science in Environmental Biology and Ecology.

Dr. P. V. Blenis (examining committee)

Aug 29, 2003

Abstract

A survey of fungi associated with the aerial portions of *Typha latifolia* plants from Alberta wetlands yielded 45 taxa. Of these, 24 are new reports from Typha and 12 are new to Canada. The potential of 32 isolates to degrade cellulose, gelatin, tannic acid, starch and lignin in pure culture was determined. Each was also grown on Typha leaf tissue samples to obtain mass loss values for native substrate. Most fungi were at least cellulolytic and higher abilities to degrade this macromolecule paralleled higher mass loss values for leaf tissues. In a study of the interaction of two of these fungi on autoclaved Typha leaf segments, *Psathyrella typhae* was the stronger competitor when paired with *Sclerotium hydrophilum*. This conclusion was based on a novel technique that distinguished the living hyphae of each species in macerated leaves using physiological characteristics expressed on 24-well microtitre plates and two differential media.

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List of Abbreviations

ALTA - University of Alberta Cryptogamic Herbarium

CAS – Casamino acid medium

CEL – Cellulose-azure method for determining cellulolytic abilities

CMA – Cornmeal agar

CMA4 – Cornmeal agar adjusted to pH 4

d-H_2O – Distilled water

DAOM - National Mycological Herbarium of Canada (Ottawa, Canada)

GEL – MMN with gelatin substituted for agar

LIG – Wood powder medium

MEA – Malt extract agar

MMN – Modified Melin-Norkrans agar

OA – Oatmeal agar

PBA – Peptone broth agar

PCA – Mixed cereal agar

PDA – Potato dextrose agar

sdH_2O – Sterile distilled water

STA – MMN supplemented with starch

TAM – Tannic acid medium

UAMH - University of Alberta Microfungus Collection and Herbarium (Edmonton, Canada)

UME – Umeå University Herbarium (Umeå, Sweden)

CHAPTER 1. INTRODUCTION

1.1 *Typha latifolia* ecology and decomposition

Typha latifolia L., or cattail, is a major detritus producer in many wetland ecosystems. *Typha* spp. are highly competitive emergent macrophytes with high primary production rates, giving them a high standing biomass relative to other macrophytes (Squires and van der Valk 1992, Brinson et al. 1981). *Typha latifolia* detritus does not accumulate as peat (Thormann et al. 1999, Yavitt 1994) because of fast decomposition rates. Most of this decomposition occurs while shoots are in a standing-dead position; 80% of leaves are still exposed to air after one season, and 10-20% after a second (Bärlocher and Biddiscombe 1996). In *Typha domigensis*, most of the degradation of this material is done by fungi (Hackney et al. 2000), and this is presumably also the case in *T. latifolia*. However, what species of fungi are involved in this process, how they interact with one another, and how they partition the substrate are poorly understood.

Typha latifolia is the only species of *Typha* in Alberta (Packer 1983), and forms dense rhizomatous mats in shallow water in marshes, ditches, and at the edges of lakes and ponds. In deeper water bodies, the 40-60 cm thick mats often fragment from natural disturbances; these portions float and sink on a seasonal cycle (King 1984) due to changes in gas solubility and anaerobic decomposition rates (Hogg and Wein 1988a,b). Decomposition of *T. latifolia* leaves begins before the end of their first year (Bärlocher and Biddiscombe 1996). Estimates of mass loss within a year range from 52% (Purvith 1980) to 64% (Thormann and Bailey 1997) using litter-bag techniques, while Bärlocher and Biddiscombe (1996) found 54.5% mass loss between September and April (7 months) using marked plants in nature.

The efficiency of decomposition in marshes is important. Experiments simulating organic matter accumulation show a reduction in macrophyte productivity (Barko and Smart 1986, 1983). This may permit the invasion of other plant species, which has been shown to destroy *Typha domigensis* populations in Cuba (Fraga and Kvêt 1993). Abiotic factors affecting decomposition in wetlands include temperature, moisture, pH, and

oxygen and nutrient levels (Gorham 1991, Farrish and Grigal 1988, Bartsch and Moore 1985, Brinson et al. 1981).

Due to the importance of the decomposition of *T. latifolia*, and the predominance of fungi on the standing shoots where the majority of decomposition occurs, I surveyed fungi occurring in this habitat in Alberta and tested the abilities of 32 species to degrade cellulose, lignin, starch, gelatin, and tannic acid using indicator media. I also tested their abilities to cause mass losses of sterilized *T. latifolia* leaves in moist chambers. In this chapter I review the knowledge of fungi inhabiting *T. latifolia*. Because the interactions that take place between fungi are major determinants of the species composition (Fredrickson and Stephanopolous 1981), which may also affect decomposition processes, I determined the effects of competition on two fungi inhabiting *T. latifolia* leaves using a new technique. Thus, in this first chapter I also present background on fungal competition and its measurement in general and in leaves. Following this, I present the main objectives of this thesis.

1.2 Fungi on *Typha* spp.

There are currently 154 fungal species and an additional 13 fungi identified to genus recorded from *Typha* spp. (Farr et al. 2002 (compiling data from 74 sources), Tokumasu 1994, Redhead 1984, Redhead 1981, Pugh and Mulder 1971). However, little is known about these fungi beyond their presence in the lists and/or the brief "habitat" section given in species descriptions (generally just the host information and geographical location(s)). Tokumasu (1994) studied the seasonal and spatial distributions of some *T. latifolia*-inhabiting fungi in a Japanese bog, but found mostly ubiquitous, highly-sporulating species, likely because he identified fungi that grew from unsterilized washed leaf fragments in culture, creating a bias towards highly sporulating species. Tokumasu found that some fungi have seasonal occurrences on the leaves and others are always present. However, these results may also simply represent seasonal sporulation patterns. No studies have investigated other aspects of the ecology of fungi on *Typha*.

1.3 Fungal competition

Competition is a major factor in shaping microbial communities (Fredrickson and Stephanopolous 1981). Interactions between fungi usually result either in deadlock or replacement (Schmit 1999), although parasitism, growth stimulation, and intermingling of hyphae with little effect on each other have also been observed (Shearer 1995). Interspecific competition (between different species) is the only type of competition being considered in this thesis, "competition" being defined as "the negative effects which one organism has upon another by consuming, or controlling access to, a resource that is limited in availability" (Keddy 1989).

Fungal interactions may be affected by factors including temperature (Marin et al. 1998a, b, Widden and Hsu 1987, Magan and Lacey, 1984, Widden 1984), water activity (Marin et al 1998a, b, Bravo-Velasquez and Hedger 1988, Magan and Lacey 1984), substrate type (Widden and Hsu 1987, Magan and Lacey 1984), inoculum size (Holmer and Stenlid 1997, 1993), and precolonization of a substrate, which may affect the spore germination rates of other fungi (Dickinson and Skidmore 1976). I chose one of these variables (temperature) and examined how two fungi from *T. latifolia* competed at 15 and 25°C.

1.3.1 Measuring fungal competition

One problem in evaluating fungal interactions is assessing the relative abundances of fungi within opaque substrates. This has led most investigators to use agar media rather than natural substrate, but these results may have little relevance to *in vivo* interactions (Fravel 1988, Webber and Hedger 1986). There are also some techniques, such as those in which precolonized substrate is placed in nature (e.g. Garrett 1950, Ahmad and Baker 1987), that have problems with design and assumptions (such as assuming that competition is the only type of interaction affecting the relative abundances of fungi in nature); these are discussed in Shearer (1995).

The most successful techniques in measuring fungal competition have been used in soil (Wardle et al. 1993) and in wood (Holmer and Stenlid 1993, 1997), but these are poorly applicable to fungi growing in leaves. Holmer and Stenlid (1993, 1997) re-combined sections of round wood discs after they had been colonized with different

fungi. These had been cut like pie slices using different sizes of sections to find the effect of inoculum size on competitive interactions. However, in wood, fungi often form interaction zones that are visible to the naked eye, which allow investigators to easily monitor the progress of the fungi. Because these lines do not form in leaves, interactions are impossible to monitor in this way. In addition, the matching up of sections may affect the continuity of the substrate and thus possibly the interactions.

Wardle et al. (1993) mixed soil pre-colonized with the competing fungi in various ratios, and after incubation used growth from washed particles and spore counts to estimate fungal colonization patterns. Spore counts may be useful when measuring competition between highly sporulating fungi, but are inapplicable to poorly or non-sporulating fungi. Competition may also increase (Porter 1924) or decrease (Tan et al. 1995, Safar and Cooke 1988) allocation to sporulation in different fungi. In addition, the mixing process could disrupt the continuity of the leaves and possibly affect the interactions. Finally, identification of the competitors was presumably done on a morphological basis, which is unsuitable for morphologically similar or intermingling fungi.

1.3.2 Measuring fungal competition in leaves

No completely satisfactory methods for measuring *in vivo* fungal interactions in leaves exist. Fokkema (1973) grew fungi together on leaf fragments and observed the changes in the surface coverage of the competitors' mycelia over time, but had difficulties distinguishing between the mycelium of different species; as well, the amount of surface growth could conceivably differ from the amount of growth occurring inside the leaves. Adhikari and Tiwari (1991) grew fungi together on leaves and compared the number of spores produced by the different fungi over time using dilution plates. Similarly, Adee et al. (1990) counted the relative number of sporocarps produced over time by two plant pathogenic fungi grown together in leaves. However, spore or sporocarp production may not necessarily reflect fungal biomass, and is inapplicable to poorly- or non-sporulating fungi, as discussed above. Conway et al. (2000) grew fungi from opposite sides of petri plates covered in leaf tissue, and analysed the growth of fungi over time in small plugs taken from midway in between the starting points. They used

ergosterol concentrations to estimate fungal biomass, and DNA analysis to identify the different species; this technique gave poor results, and was imprecise, as only a single midpoint was analyzed. A more promising method was used by Widden and Hsu (1987), who cut leaf strips into 2 mm segments (following inoculation, incubation, and surface sterilization), the segments then being placed on agar medium and assessed for growth of either or both species. The only problems with this method are that precision is limited by the size and number of segments cut and plated, and visually indistinguishable fungi again cannot be used.

1.4 Objectives

A survey of fungi inhabiting standing *T. latifolia* shoots was conducted, to identify some of the species present in Alberta. Cultures were established from fruiting bodies found on field material and from fungi growing in moist chambers containing surface-sterilized leaves. To determine the portion of the substrate most likely targeted by these fungi, 32 species were tested for the ability to degrade cellulose, gelatin, starch, lignin, and tannic acid using indicator media, and to cause mass losses in autoclaved *T. latifolia* leaves. This material forms the basis of Chapter 2.

The second objective was to investigate spatial partitioning within *T. latifolia* leaves; that is, how the fungi physically interact with one another in the substrate. To do this, a new technique was developed that overcame many of the shortcomings of previous methods, and was applied to two *T. latifolia*-inhabiting fungi, *Psathyrella typhae* and *Sclerotium hydrophilum*. My purpose was to determine the outcome of competition between these fungi, and rationalize these results with putative life-history strategies. This is presented in Chapter 3.

In Chapter 4 the most important findings of my investigations are summarized and synthesized, and directions for further research based on the results are presented. A glossary of mycological and descriptive terms used in this thesis is given in Appendix 1.

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CHAPTER 2. SOME SAPROBIC FILAMENTOUS FUNGI FROM *TYPHA LATIFOLIA* IN ALBERTA, CANADA

2.1 Introduction

Typha latifolia L., or cattail, is a highly productive emergent macrophyte (Brinson et al. 1981) and a major source of detritus in many wetland habitats. Fungi are probably the dominant decomposers of the standing dead biomass (Hackney et al. 2000) produced by this species but information regarding which fungi might be involved in this process and what components of the substrate they degrade is sparse.

I undertook a survey of the fungi on *T. latifolia* in some southern boreal wetlands in central Alberta by collecting and identifying sporocarps from the field, by preparing cultures from these specimens, and by making isolates from cryptic thalli present in dead and living shoot tissues. During two successive field collections in 2001, 45 different fungi were identified. Four of these were isolated from the sporocarps of other species, 26 were from field specimens, and 9 from surface-sterilized material in moist chambers. Six additional taxa were found in both field material and moist chambers.

Selected fungi that had been established in culture were examined with respect to their growth and reactions on various media to determine if they had the ability to decompose cellulose, gelatin, starch, tannic acid, and lignin. Sets of sterile, dried, leaf tissues were also inoculated axenically with fungal isolates to obtain an indication of their potential ability to cause mass losses of *T. latifolia* in nature.

2.2. Materials and methods

2.2.1 Study area

Three sites within Elk Island National Park (EINP), Alberta, Canada, were chosen to represent a diverse range of *T. latifolia* habitats in order to maximize the number of species collected within a short period of time. These included a pond, a marsh, and a temporary lake (for details see species descriptions below). *Periconia typhicola*, *Hymenopsis typhae*, *Hyphoderma sambuci* and *Psathyrella typhae* were obtained in November 1999 and/or May 2000 from *T. latifolia* floating mats in a

beaver pond just outside of the eastern border of EINP during a previous study by other investigators (Ann Smreciu, Wildrose Consulting, Edmonton, Alberta and Markus Thormann, Northern Forestry Center, Edmonton, Alberta).

2.2.2 Sampling, isolation, and identification

Samples were collected June 27 and Sept 27, 2001 by taking random walks through each site looking for fungal fruiting bodies on *T. latifolia* plants. Fungi were collected by cutting out the entire section of substrate on which fruiting bodies appeared. In addition, two plants, one live (current year's growth) and one dead (previous year's growth), were cut at the base and collected from each site for use in moist chamber incubations.

Moist chambers were prepared by rinsing the collected *T. latifolia* plants to remove attached debris, and taking 6 cm sections starting at the base and at intervals of 30 cm (yielding sections 0, 36, 72, and 108 cm from the base). Sections were peeled apart to separate the sheathing leaves and culm (if present), surface-sterilized (by washing in 70% ethanol for approximately 30 seconds followed by rinsing in sterile distilled water (sdH_2O)), and incubated on dampened filter paper in 8.5 cm diameter plastic petri plates. Moist chambers were incubated in the dark at 25°C and monitored for fungal growth. Fungal fruiting bodies and vegetative growth developing on these sections were used to establish pure cultures. Collection sites and sources of fungi are given in species descriptions, but were not subject to analysis because replicate numbers were low.

Fruiting bodies from both moist chambers and field collections were identified on the basis of microscopic characters. Pure cultures were obtained using various techniques (see below) and plated onto Malt Extract Agar (MEA, Difco) amended with oxytetracycline (0.01%) to suppress bacterial growth.

Sporocarp-forming basidiomycetes were cultured using surface-sterilized (as above) stipe explants. Discomycetes were washed with sdH_2O (if approximately 2 mm diameter or less) or surface-sterilized (if larger) before being used as inoculum. Perithecial ascomycetes, coelomycetes, and macroscopically visible hyphomycetes were plated directly from spores or spore masses, or from fruiting bodies that had been washed in sdH_2O and/or were surface-sterilized. Sterile colonies were induced to sporulate by refrigeration, exposure to black (UV) light, and growing on various media including oatmeal agar (OA, 20.0 g oatmeal (Quaker, large flakes), 20.0 g agar

(Difco), 1.0 L distilled water (d-H_2O)), mixed cereal agar (PCA, 100.0 g mixed cereal (Pablum®, H. J. Heinz Company of Canada Ltd.), 15.0 Difco agar, 1.0 L d-H_2O), potato-dextrose agar (PDA, Difco) corn meal agar (CMA, Difco), and sterilized *T. latifolia* leaves on water agar (17.0 g Difco agar, 1.0 L d-H_2O). Fungi were identified either from direct mounts, hand or freezing-microtome sections of fruiting bodies (for some coelomycetes), or slide cultures (Sigler 1993) on PCA. Isolates were stored on slants of CMA at 4°C.

New records for fungi were determined by searching current databases (i.e. Farr et al. 2002, Biological Abstracts, and Biological Sciences Internet databases) and the most recent literature sources listing fungi from *Typha* spp. or suspected taxa (see descriptions).

2.2.3 Degradation of selected macromolecules

Macromolecules selected for degradation tests included cellulose, starch, lignin, tannic acid, and gelatin. Each test was visually ranked on a four-point scale, with "0" indicating no reaction, and "3" the strongest reaction of those observed (for details see below), relative to uninoculated controls. Plates were inoculated using a 5.5 mm plug of mycelium taken from the edge of a growing colony on CMA, using the top end of a sterile glass Pasteur pipette plugged with cotton. Tests indicated enzyme production from new fungal growth occurring on the indicator media, possibly with a small amount of enzymes leaching from growth on the plugs. Three replicates of each isolate were made and the strongest positive result from each isolate was recorded.

Cellulolytic abilities were tested using the cellulose-azure method (CEL, Smith 1977), with modified Melin-Norkrans agar (MMN, 1.0 g glucose, 2.0 g malt extract, 1.0 g yeast extract, 0.5 g KH_2PO_4, 0.25 g $(NH_4)_2HPO_4$, 0.15 g $MgSO_4 \cdot 7H_2O$, 0.05 g $CaCl_2$, 0.025 g NaCl, 0.012 g $FeCl_3 \cdot 6H_2O$, 15.0 g agar, and 1 L d-H_2O) substituted as the nutritive medium (Hutchison 1990). Approximately 15 mL MMN was added to 25 mL scintillation vials, allowed to solidify, and approximately 1-1.5 mL of 2% (w/v) cellulose-azure in MMN placed on top. The degradation of cellulose fibers complexed with the purple dye in the cellulose-azure released the dye into the basal medium after 12 weeks incubation. Tests were ranked according to the darkness of the shade of purple in the basal medium as compared to the cellulose-azure in MMN on top; "0" was ranked when the lower phase was the same as the controls, "1"

when a reaction was slightly more purple than the controls but substantially less coloured as the top, "2" when the lower phase was almost as purple as the top, and "3" was ranked when both top and bottom phases were the same.

Starch degradation was assessed using MMN containing 2.0 g/L soluble starch (STA) (Hutchison 1990). After a maximum of five weeks incubation (faster-growing fungi were tested when the mycelium covered approximately two-thirds of the plate), plates were briefly flooded with a dark-brown iodine solution (5.0 g KI in 1.5 g I/100 mL d-H_2O), which binds to the starch remaining in the medium. Negative tests turned the medium dark-brown, while positive reactions gave a clear zone with an otherwise bluish background. Tests were ranked according to the degree of clearing, with "0" indicating no clearing, "1" a barely discernable clear ring, "2" a highly visible ring, and "3" indicating that the entire plate was clear.

Wood powder medium (LIG, 0.01 % (v/v) guaiacol, 0.2 % (w/v) spruce (*Picea* sp.) wood powder, and 1.8 % (w/v) Difco agar in d-H_2O) (modified from Miyamoto et al. 2000) was used to indicate lignolytic abilities. Positive reactions were indicated by a reddish brown pigment on a colourless medium, caused by the reaction of extracellular lignolytic polyphenol oxidases with guaiacol. Plates were monitored weekly for five weeks. Tests were ranked according to the proportion of the plate with the pigment present and the darkness of the pigment, with "0" indicating no pigmentation, "1" light pigmentation around the base of the plug, "2" dark pigmentation extending up to halfway from the inoculum plug to the perimeter of the plate, and "3" dark pigmentation extending more than halfway to the perimeter of the plate.

The ability to degrade tannic acid was tested using tannic acid medium (TAM, 5.0 g tannic acid (Baker analyzed), 15.0 g Difco malt extract, 20.0 g Difco agar, 1.0 L d-H_20) (Davidson et al. 1938). After three days, a dark brown pigment released into an otherwise cream-coloured medium was caused by a positive reaction between oxidase and tannic acid. Tests were ranked according to the proportion of the plate with the pigment present and the darkness of the pigment, with "0" indicating no pigmentation, "1" light pigmentation around the base of the plug, "2" dark pigmentation extending up to halfway from the inoculum plug to the perimeter of the plate, and "3" dark pigmentation extending more than halfway to the perimeter of the plate.

Gelatin degradation was tested using MMN containing 120 g/L gelatin instead of agar (GEL, Hutchison 1990). The degradation of the gelatin disrupted the integrity of the medium and was indicated by "gel" formation causing a depression in the "sol" (semi-solid) medium and/or liquid accumulation upon inversion of the plate. Tests were ranked according to the proportion of the plate converted to gel and the amount of liquid produced, with "0" indicating no gel formation, "1" gel formation extending up to halfway from the inoculum plug to the perimeter of the plate (with no liquid accumulation), "2" gel formation extending over halfway to the perimeter of the plate without considerable liquid accumulation, and "3" considerable liquid accumulation.

2.2.4 Decomposition of *T. latifolia* leaves and calculation of mass losses

The abilities of the fungi to cause mass losses of *T. latifolia* leaves were tested using green leaves, air-dried to a constant weight, and cut into approximately 8.5 cm long fragments. Weighed 1.00 ± 0.10 g portions containing multiple leaf sections were autoclaved and placed on Peptone Broth Agar (PBA, 20.0 g Difco agar, 1.0 g Difco peptone-broth, 1.0 L d-H_2O) in 8.5 cm diameter plastic petri plates, and inoculated with one plug (as outlined above) in the centre and three at the edge of the plate. Three replicates were prepared for each isolate. Controls (containing no inoculum) were run simultaneously. After 12 weeks incubation at 25°C in the dark, agar plugs were removed and the leaves were dried to a constant weight. Contaminated replicates were discarded. Percentage mass losses were calculated after adjusting for the 18% mass loss due to leaching from the controls.

2.3 Results

Forty-one species including five basidiomycetes, 18 ascomycetes, and 18 mitosporic fungi (12 hyphomycetes and six coelomycetes) were collected and/or isolated from *T. latifolia*. Four additional species were isolated from the sporocarps of other fungi growing on *T. latifolia*. No zygomycetes or chytridiomycetes were found. Of the 37 fungi identified to species, 24 are new reports from *Typha* spp., and at least 12 are new to Canada. Seven species are new to North America, and the records for *Albotricha acutipila*, *Hyaloscypha glyceriae*, *Phaeosphaeria typhae*, *Periconia typhicola*, and *Rivilata ius* are the first outside of the country of their type locality. *Phialophora melinii Talaromyces ohiensis*, *Coprinopsis radiata*, and *Hyphoderma*

sambuci had not been recorded previously from leaves. An arthroconidial anamorph was discovered for *Psathyrella typhae*, and Acremonium-like anamorphs were discovered for *A. acutipila* and perhaps also for a species of *Tapesia*. Thirty-seven species were established in pure culture, and 32 of these were tested for their abilities to degrade selected macromolecules and *T. latifolia* leaves. The results of enzymatic tests are given in species descriptions below, and enzymatic and mass loss results for all species are presented, along with isolation and deposition information, in Appendix 2. Cellulose degradation was observed in 35 of the 36 isolates, while 31 degraded gelatin, 27 starch, 22 tannic acid, and 21 lignin.

2.4 Discussion

This study provides 12 new reports of fungi in Canada, and at least 24 on *Typha* spp. Four are new reports on leaves, seven are new reports from North America, and five are new outside the country of their type locality, extending the geographical and/or host range of these fungi. Species such as *Psathrella typhae*, *Verticillium lecanii*, *Alternaria alternata*, and *Aureobasidium pullulans* were reported during previous surveys of fungi on *T. latifolia* and other wetland monocots (Tokumasu 1994, Redhead 1981), but records of some taxa were of particular interest. For example, *T. ohiensis* was known only from two isolates from soil, in Japan and Ohio (Huang and Schmitt 1975), and the record for *R. ius* is the first apart from the collections cited in the original description. Although the limited collection period made estimations of abundance moot, *Cladosporium herbarum*, *Phoma typhicola*, *H. glyceriae*, *Mollisia* sp., and *Stagonospora vitensis* were regularly observed in field and/or laboratory material (data not shown), suggesting that these were common colonizers of *T. latifolia*. Although *V. lecanii*, *Podospora* cf. *glutinans*, cf. *Bjerkandera adusta*, and *Thielavia terrestris* were isolated from sporocarps of other fungi, *V. lecanii* has been reported from *T. latifolia* previously (Tokumasu 1994) and *Podospora* spp., *B. adusta*, and *T. terrestris* are common saprotrophs from dung, wood, and soil/plant material respectively, as were several other fungi isolated directly from the material (e.g. *Sordaria fimicola* and *Phialophora melinii*).

The previously undescribed anamorphic stages for *Psathyrella typhae*, *A. acutipila*, *P.* cf. *glutinans*, and *Tapesia* sp. are similar to those reported from closely related species: *Psathyrella typhae* produces arthroconidia like other species of

Psathyrella (see Kendrick and Watling 1979), and *Tapesia* sp. and *A. acutipila* produce phialidic conidiophores like other members of the Helotiales (see Kendrick et al. 1979). The arthroconidia of *P. typhae* are produced in a distinctive pattern of four chains of two conidia each at the terminus of conidiophores (see Fig. 2.9). The Acremonium-like anamorphs of *Tapesia* sp. and *A. acutipila* require further analysis for designation in a hyphomycete genus.

In contrast to findings by Osono and Takeda (2002) that only 8 of 79 diverse fungi from beech litter were able to cause more than 10% mass loss (in eight weeks at 20°C), and most produced mass losses below 5%, my study had a fairly continuous distribution between 54.6 and –0.4% mass loss (Appendix 2). Osono and Takeda also found that the best decomposers were basidiomycetes, and in particular Agaricales (up to 57.6% mass loss), with members of the Xylariaceae being the next best (up to 14.4% mass loss). Although my study showed similar high mass losses for the Agaricales *Psathyrella typhae* and *Coprinopsis radiata*, and the basidiomycete *Hyphoderma sambuci*, similar or higher mass losses were caused by *Acremonium* sp. and cf. *Hyaloscypha glyceriae*.

Hackney et al. (2000) found that fungi were the dominant decomposers of standing-dead *T. latifolia* leaves. The high mass losses obtained in this study are consistent with fungi being capable of producing high decomposition rates for *T. latifolia* leaves, such as those obtained by Bärlocher and Biddiscombe (1996, 54.5% mass loss in seven months).The mass loss due to leaching (18%) was slightly higher than the estimated 14-16% for *Typha glauca* Godr. (Nelson et al. 1990).

The enzymatic test results from in vitro studies are limited by the use of crude tests that may or may not represent the enzymatic activity of fungi in the leaves; however, positive results from these tests clearly demonstrate that the isolates are capable of producing the enzymes under some conditions. Another limitation was the use of autoclaved material in mass loss determinations, which may have been chemically altered, although Tsuneda et al. (2001) found no discernable changes to *Sphagnum* leaf morphology after autoclaving. Finally, mass losses were estimated using dried green leaves under laboratory conditions, and some fungi may be better at decomposing material at different stages of decomposition or under different conditions.

2.5 Annotated list of taxa

Genera and species are listed alphabetically, followed by the authority, citation, and taxonomic affiliation (Family, Order). Distinguishing characteristics for each fungus include more information for less common species or fungi not previously recorded from the substrate or in Canada. Descriptions are not given for *A. alternata*, *A. fumigatus*, *A. pullulans*, *C. cladosporioides*, *C. herbarum*, *E. nigrum*, *Fusarium sporotrichioides*, *S. fimicola*, *S. minima*, *T. terrestris* and *Verticillium lecanii* due to their ubiquity (although the records for *A. fumigatus*, *C. cladosporioides*, *S. fimicola*, and *S. minima* were the first for this substrate). Detailed information and/or illustrations are also not given for some fungi identified by other researchers. Enzymatic capabilities and cultural information are original data; references indicate studies with supporting results. Colony descriptions are given first if the descriptions are based on pure cultures, but after fruiting body characters if descriptions are based on sporocarps from field collections. Notes include isolation information, the literature on which identifications were based, and notes on the frequency of taxa on *T. latifolia* in my study area, if known, based on field and lab observations. The ecological and geographical distributions of species, including relevant prior reports, are based on published reports as described previously. Collection numbers begin with the prefixes M, MS, MJS, or RAM, and herbarium abbreviations include ALTA (University of Alberta Cryptogamic Herbarium), UAMH (University of Alberta Microfungus Collection and Herbarium, Edmonton), DAOM (National Mycological Herbarium of Canada, Ottawa), and UME (Umeå University Herbarium, Umeå, Sweden). Abbreviations are given at the front of this thesis, and a list of mycological and descriptive terms is given in Appendix 1. Drawings are made from squash mounts unless otherwise noted.

2.5.1 Basidiomycota

cf. *Bjerkandera adusta* (Willdenow:Fries) Karsten, 1879, Meddelanden af Societas pro fauna et flora Fennica 5:38 Figs 2.1-2.2

(Coriolaceae, Poriales)

Colony on MEA white, floccose, with abundant terminal schizolytic arthroconidia (Fig. 2.1*a*), >85 mm diam. in 7 days at room temperature, hyphae unclamped,

chlamydospores produced in similar fashion to arthroconidia in older cultures (Fig. 2.1*b*). *Conidia* elliptical to oblong with truncate apices (Fig. 2.2*a*), hyaline, multi-guttulate, smooth, 4-7 x 3-4 µm. *Chlamydospores* globose to subglobose (Fig. 2.2*b*), occasionally with truncate apices, similar to conidia but with fewer, smaller guttules and larger in size, 5.5-10 x 4-7 µm. My isolate does not produce laccase, which is consistent with Stalpers (1978), and did not use tannic acid (Wang and Zabel 1990). Gelatinolytic, poorly cellulolytic.

Material accessioned: CANADA: Alberta: Elk Island National Park: On *Gerronema marchantiae* growing on *Typha latifolia* (MS-29/ALTA 13096).

Notes: Isolated from surface-sterilized stipe explants of *L. marchantiae* collected Sept. 27, 2001 from bases of *T. latifolia* plants growing with *Marchantia polymorpha* in Site 2, a large *T. latifolia*-dominated marsh with no open water (53°39'80"N, 112°51'80"W). Identified using Stalpers (1978) and Wang and Zabel (1990) with colony characteristics, and ITS 1 sequence analysis BLAST searched on NCBI Genbank, with a 99% match to gi|21666956|gb|AF455521.1, 291/293 identities. This isolate matches well except colony morphology and odour are not consistent with *B. adusta* (Lynne Sigler, pers. comm.). *B. adusta* is reported from wood and is cosmopolitan (Farr et al. 2002).

Coprinopsis radiata (Bolton) Redhead, Vilgalys and Moncalvo, 2001, Taxon 50: 230

Figs 2.3-2.6

(Psathyrellaceae, Agaricales)

Colony on Oatmeal agar (OA) white, floccose, producing sporocarps within 5 days, hyphae unclamped. *Pileus* 2-6 mm diameter, bell-shaped, spreading to >12mm, when immature covered in long white hairs sometimes forming a toothed pattern (Fig. 2.3), when mature glabrous with some white hairs, white at margin becoming tan towards the center, deliquescing within 24 hours. *Lamellae* white, becoming black in age. *Stipe* 60-70 x 2-3 mm, equal, markedly striate at maturity, immature covered in white hairs (Fig. 2.3), mature almost glabrous, white. *Basidiospores* oval to ellipsoidal (Fig. 2.4), black, with 1-2 large faint oil droplets, with large (to 1.5 µm diameter) central germ pore and an apiculus at opposite end, 11-13 x 6.5-7 µm (l/w 1.6-2). *Basidia* (14) 15-18 (20) x (5) 8-9.5 µm, with 4 sterigmata, unclamped at base. *Cheilocystidia*

globose to subglobose (Fig. 2.5), hyaline, smooth, 16-20 x 14- 18 µm. *Veil hyphae* inflated (Fig. 2.6), elongate, constricted at the septa, to 14.5 µm wide x 79 µm long, with occasional clamp connections. Gelatinolytic, cellulolytic, utilizes starch. **Material accessioned: CANADA: Alberta:** Elk Island National Park: *Typha latifolia* leaves (MJS-6/ALTA 13100).

Notes: Isolated from surface-sterilized *T. latifolia* culm in moist chamber. Culm collected June 27, 2001 in EINP. Isolated from Site 1, a small pond surrounded by a wide (approximately 4-6 m) border of *T. latifolia* (53°42'35"N, 112°52'00"W), from standing-dead material 114 cm from the base. Identified using Breitenbach and Kränzlin (1995) and Ulgé (2003). Reported from dung (Breitenbach and Kränzlin 1995, Uljé 2003). Cosmopolitan. First record from leaves.

Hyphoderma sambuci (Persoon) Jülich, 1974, Persoonia 8: 80

(Hyphodermataceae, Stereales)

Basidiocarp white, resupinate, hyphae clamped and covered with large amounts of mineral matter. *Basidiospores* hyaline, smooth. *Cystidia* captitate, with exudate. *Colony* on MEA white, floccose, reaching ≥85 mm diameter in 10 days, reverse yellow. Gelatinolytic, cellulolytic, lignolytic, utilizes starch and tannic acid. **Material accessioned:** None

Notes: Collected November 1999 and/or May 2000 from *T. latifolia* floating mats in a beaver pond on the eastern border of EINP (53°40'N, 112°44'W). Identified by Peter Roberts, Royal Botanic Gardens, Kew. This species may represent a species complex. Reported from wood (Langer and Oberwinkler 1993). Cosmopolitan. First record from leaves.

Loreleia marchantiae (Singer and Clémençon) Redhead, 2002, Mycotaxon 82: 162

Figs 2.7-2.8

(Marasmiaceae, Agaricales)

Pileus 1-4 mm diameter, umbilicate when mature (Fig. 2.7), orange-brown to yellow-orange. *Lamellae* whitish to translucent yellow, thick, widely spaced (Fig. 2.7). *Stipe* 7-30 x 0.75-1 mm, straight or irregularly curved (Fig. 2.7), smooth and shiny with

some bumps towards the top, light translucent yellow. *Basidiospores* elliptic (Fig. 2.8), hyaline, smooth, (6) 8-12 x 4.5-6 µm. *Basidia* cylindric-clavate, with 4 sterigmata, lacking basal clamp.

Material accessioned: None

Notes: Collected Sept. 27, 2001 from bases of *T. latifolia* plants growing with *M. polymorpha* at Site 2, a large *T. latifolia*-dominated marsh with no open water (53°39'80"N, 112°51'80"W). Identified using Brietenbach and Kränzlin (1991). Reported from decaying vegetation in damp places among or near *M. polymorpha* in Europe (Breitenbach and Kränzlin 1991). First record from *Typha* spp. and in North America.

Psathyrella typhae (Kalchbrenner) Pearson and Dennis, 1948, Transactions of the British Mycolological Society 31: 185 Figs 2.9-2.10

(Psathyrellaceae, Agaricales)

Pileus 0.5-1.7 cm diameter, bell-shaped, fragile, orange-tan drying lighter, striate and translucent when moist. *Lamellae* lighter than pileus, widely-spaced with alternating intermediates, sinuate. *Stipe* 25-35 x 1 mm, fragile, hollow, yellowish. *Basidiospores* oval, golden, 10-15 x 5-6.3 µm, often highly guttulate. *Colony* on CMA white, adpressed and submerged, >85 mm after 10 days. Hyphae mostly clamped. Unclamped hyphae on pH4 CMA when paired with *Sclerotium hydrophilum* occasionally bearing *Arthrographis*-like arthroconidial conidiophores. *Conidiophores* hyaline, smooth, dry, with 4 terminal branches consisting of two conidia each (Fig. 2.9), 3-27 x 2-2.5 µm. *Conidia* 3-5 x 2-3 µm, hyaline, smooth. *Aleuroconidia* subglobose to oval or slightly curved (Fig. 2.10), with one side truncate, sometimes with a short neck. *Arthroconidia* oblong-cylindrical to barrel-shaped with apices truncate (Fig. 2.10). Gelatinolytic, cellulolytic, lignolytic, utilizes starch and tannic acid.

Material accessioned: CANADA: Alberta: Near Elk Island National Park: *Typha latifolia* leaves (RAM-3-AR1/UAMH 10280, RAM-4-AS2/10281).

Notes: Basidiocarp information from specimens collected June 27, 2001 on damp, highly-decomposed *T. latifolia* plants at Site 2, a large *T. latifolia*-dominated marsh

with no open water (53°39'80"N, 112°51'80"W). Cultural information from strains collected from a beaver pond at 112°44'W, 53°40'N, just east of EINP, November 1999/May 2000, from stipe explants. Identified using Brietenbach and Kränzlin (1991) and Redhead (1979). Reported from many wetland plants and the soil surrounding them in North America and Europe (Redhead 1979).

Sclerotium hydrophilum Saccardo *apud* Rothert, 1892, Botanische Zeitung (Berlin) 50: 321 Figs 2.11-2.12

Colony on CMA with sparse whitish aerial mycelium, producing black sclerotia. *Sclerotia* reddish-brown to black, mostly globose and 400-600 µm in diameter (but may form larger fused clusters), consisting a dark rind of inflated, mostly globose cells (2-4 cells and 5-7.5 µm thick) and a medulla of hyaline to yellowish, highly-branched inflated elongate hyphae (Figs 2.11-2.12). Sclerotia are formed by the production of clusters of white, loosely-woven hyphae which become covered in a reddish-brown rind that eventually turns black. Gelatinolytic, cellulolytic, lignolytic, utilizes starch and tannic acid.

Material accessioned: CANADA: Alberta: Elk Island National Park: *Typha latifolia* leaves (M-32/UAMH 10282, MJS-28/ALTA 13117).

Notes: Isolated from surface-sterilized *T. latifolia* leaves in moist chambers. Leaves collected June 27, 2001 from Site 1, a small pond surrounded by a wide (approximately 4-6 m) border of *T. latifolia* (53°42'35"N, 112°52'00"W), from outer material at the base of standing-dead plant. Identified using Punter et al. (1984). Reported from soil, hair, and plants in wetlands (Punter et al. 1984). Cosmopolitan.

2.5.2 Ascomycota

Albotricha acutipila (Karsten) Raitviir, 1970, Scripta Mycologica 1: 40 Figs 2.13-2.16

(Hyaloscyphaceae, Leotiales)

Apothecia short-stipitate to sessile (Fig. 2.13), deeply cupulate with dentate margin of clustered white hairs, 300-350 µm diameter, stipe to 108 µm long and 113 µm wide, white. *Hairs* cylindrical with apical cell inflated and usually slightly pointed (Fig. 2.14), hyaline, smooth, septate, protruding about 25 µm beyond ascus layer (total

about 60 µm long), 3-4 µm wide, thin-walled. *Asci* 8-spored, clavate (Fig. 2.15), 32-37 x 4-5 µm. *Ascospores* uni- becoming biseriate (Fig. 2.15), fusiform to allantoid or irregularly shaped (Fig. 2.16), hyaline, minutely guttulate, smooth, (4) 5-7 (8.2) x 1-2 µm, aseptate. *Paraphyses* infrequent, filiform with equal to clavate tips (Fig. 2.15), usually with 3 septa, to 2 µm wide. *Colony* on MEA purplish, darker towards the center, with distinct white margin and close, distinct zonations, aerial mycelium sparse, margin slightly irregular, 16 mm diameter at 10 days, producing anamorph (see below), some hyphae covered in masses of minute black crystals.
Anamorph: Acremonium-like. *Phialides* single, clustered, or protruding from masses of clustered cells. *Conidia* produced in slimy heads, fusiform to cylindrical or irregularly shaped, hyaline or with purple guttules, guttules mostly in smaller spores, smooth or rarely covered in masses of minute black crystals, 4-11 x 0.6-2.2 µm, aseptate, often undergoing microcyclic conidiation.
Material accessioned: None

Notes: Collected September 27, 2001 from Site 3, a small temporary lake with *T. latifolia* forming a thin (<1 m wide), patchy border along with water arum (*Calla palustris* L.) and sedges (*Carex* sp.) (53°41'50"N, 112°48'60"W). Found near base of standing-dead *T. latifolia* plant. Identified by Seppo Huhtinen, Herbarium, Center for Biodiversity, University of Turku, Finland. Reported from *Phragmites* and *Digraphis* in the United Kingdom (Dennis 1978, Dennis 1986). First record from *Typha* spp. and outside of the United Kingdom.

***Cistella* sp.** Figs 2.17-2.20

(Hyaloscyphaceae, Leotiales)

Apothecia cupulate, sessile with white marginal hairs (Fig. 2.17), white, approximately 120 µm diameter. *Hairs* hyaline, ornamented with warts (Fig. 2.18), 4-7 µm wide. *Asci* 8-spored, cymbiform (Fig. 2.19), 30 x 3.5-4.5 µm. *Ascospores* biseriate (Fig. 2.19), irregularly fusiform (Fig. 2.20), often with one end more tapered than the other, sometimes slightly curved, hyaline, smooth, 7-9 x (1) 1.2-1.4 (1.8) µm, aseptate.
Material accessioned: CANADA: Alberta: Elk Island National Park: *Typha latifolia* leaves (MS-1/ALTA 13097).

Notes: Collected September 27, 2001 at the base of *T. latifolia* plant in EINP at Site 2, a large *T. latifolia*-dominated marsh with no open water (53°39'80"N, 112°51'80"W).

Hyaloscypha glyceriae Velenovský, 1934, Monographia discomycetum Bohemiae, p. 279 Figs 2.21-2.24

(Hyaloscyphaceae, Leotiales)

Apothecia sessile (Fig. 2.21) or with a very short, thick stipe, cupulate with white marginal hairs, (200) 340-400 (1000) µm diameter, white. *Hairs* hyaline, spiny (Fig. 2.22), 10-15 x 4-9 µm. *Asci* 8-spored, 35-50 x 8-10 µm, with a pronounced central to sometimes eccentric apical pore when mature (Fig. 2.23). *Ascospores* bi- to tri-seriate (Fig. 2.23), fusiform to bacilliform with ends often tapered slightly (Fig. 2.24), hyaline, guttulate, smooth, 0-2 (3)-septate, with 0-septate spores 9-11 x 2.5-3 µm, 1-septate spores 12-14 x 3.0-3.5 µm, and 2-3-septate spores 15-19 x 3 µm. *Paraphyses* equal or with slightly clavate tips (Fig. 2.23), 2-3 septate, similar in height or slightly higher than asci.

Material accessioned: CANADA: Alberta: Elk Island National Park: *Typha latifolia* leaves (MJS-9/ALTA 13105, MJS-10/13106, MJS-11/13107).

Notes: Collected June 27 and September 27, 2001. Common at the bases of *T. latifolia* plants in EINP. Identified by Seppo Huhtinen, Herbarium, Center for Biodiversity, University of Turku, Finland. This fungus likely belongs in the genus *Cistella* (S. Huhtinen, pers. comm.). Reported from *Glyceria* and *Scirpus* in the Czech Republic (Velenovský 1934). First record from *Typha* spp. and outside of the Czech Republic.

cf. *Hyaloscypha glyceriae* Velenovský, 1934, Monographia discomycetum Bohemiae, p. 279 Figs 2.25-2.28

(Hyaloscyphaceae, Leotiales)

Apothecia sessile, solitary to gregarious and occasionally with two apothecia from the same base, cupulate, with white marginal hairs forming a dentate pattern, 300-500 µm diameter, white, when dried yellowish and with white warts on outer surface (Fig. 2.25). *Hairs* hyaline, ornamented with spines (Fig. 2.26), 5-7 µm wide. *Asci* 2-, rarely

4-spored, clavate with a blunt apex (Fig. 2.27), 33-42 x 5-7.5 µm. *Ascospores* fusiform (Fig. 2.28), straight or rarely slightly curved, hyaline, guttulate with one guttule per cell, smooth, 3-septate, (12) 14-22 (23.5) x 3-3.5 (4.0) µm. *Paraphyses* rare, with swollen but pointed tips (Fig. 2.27), 1-2-septate, 36-38 x 1-2.5 µm.
Material accessioned: None

Notes: Collected June 27, 2001 near the base of *T. latifolia* plant in EINP. This fungus differs from *H. glyceriae* primarily in having 2- (rarely 4-) spored asci and having 3-septate spores, and may represent an aberrant population.

Hymenoscyphus repandus (Phillips) Dennis, 1964, Persoonia 3: 75 Figs 2.29-2.31
(Helotiaceae, Leotiales)
Apothecia deeply cupulate, stipitate with stipe tapering towards base, cup margin rimose (Fig. 2.29) to smooth, 0.7-1.0 mm tall x 530-550 µm wide, translucent yellowish. *Asci* 8-spored, clavate (Fig. 2.30), 32-38 x 3.5 x 4.2 µm. *Ascospores* biseriate (Fig. 2.30), irregularly cylindrical (Fig. 2.31), often slightly curved, hyaline, sometimes with small guttules, smooth, (6) 7-8 (9) x 1.2-2.0 µm, 0-1 septate. *Paraphyses* equal (Fig. 2.30), mostly 3-4 septate, slightly shorter than asci, 2-3 µm wide. *Colony* on CMA white, with little aerial mycelium. Older cultures occasionally with yellowish erect structures resembling aborted ascocarp initials. Gelatinolytic, utilizes starch.
Material accessioned: None

Notes: Collected June 27, 2001 at bases of *T. latifolia* plants at Site 2, a large *T. latifolia*-dominated marsh with no open water (53°39'80"N, 112°51'80"W). Identified using Brietenbach and Kränzlin (1981). Reported from many plants in the USA (Farr et al. 2002) and Europe (Brietenbach and Kränzlin 1981, Dennis 1986, 1978, Torres et al. 1982). First record from *Typha* spp. and in Canada.

Hymenoscyphus scutulus (Persoon:Fries) Phillips, 1887, British Discomycetes p.137
Figs 2.32-2.35
(Helotiaceae, Leotiales)

Apothecia slightly cupulate to flat or convex (Fig. 2.32), stipitate with an equal stipe, 0.6-4 (7) mm tall x 0.25-1.0 mm wide, disc yellow-orange to yellow, stipe white, longer stipes in specimens growing from in between basal sheathing leaves (Fig. 2.33). *Asci* 8-spored (Fig. 2.34), clavate, 85-109 x (6) 7-8 µm. *Ascospores* biseriate (Fig. 2.34), fusiform, apices generally pointed and directed laterally, usually with ends pointing laterally in the same direction, sometimes with short projections from the points (Fig. 2.35), hyaline, usually with small and medium-sized guttules, smooth, (18) 22-24 x 3-4 (4.5) µm, 0- to rarely 1-septate. *Paraphyses* equal to slightly capitate (Fig. 2.34), mostly 2-3 septate, longer than asci, 1.5-2.0 µm wide. *Colony* on CMA white with dark olivaceous center, 9 mm at 10 days. Gelatinolytic, cellulolytic, lignolytic, utilizes starch.

Material accessioned: None

Notes: Collected Sept 27, 2001 at or near bases of *T. latifolia* plants at Site 2, a large *T. latifolia*-dominated marsh with no open water (53°39'80"N, 112°51'80"W). Identified using Brietenbach and Kränzlin (1981). Reported from dicotyledonous debris (Farr et al. 2002) and submerged, decomposed *Scirpus atrovirens* Willd. stems (Fallah and Shearer 2001), in temperate regions (Farr et al. 2002). First record from *Typha* spp. and in Canada.

Iodophanus carneus (Persoon:Fries) Korf, 1969, *in* Kimbrough and Korf, American Journal of Botany 56: 1196 Figs 2.36-2.39

(Pezizaceae, Pezizales)

Apothecia sessile (Fig. 2.36), with sparse hairs protruding from sides, globose becoming shallowly cupulate upon maturity, texture gelatinous, 1.1-1.5 mm wide by 0.5-1.0 mm high, pinkish with sparse white hairs. *Hairs* smooth and 20-25 x 1 µm on small apothecia (Fig. 2.37*a*), to roughened and about 155 x 5-10 µm on larger apothecia (Fig. 2.37*b*), hyaline. *Asci* 8-spored, equal becoming clavate in age (Fig. 2.38), bluing slightly over entire surface in Melzer's reagent, 194-213 x 13-17.5 µm, with gelatinous covering. *Ascospores* uniseriate becoming biseriate in age (Fig. 2.38), oval (Fig. 2.39), hyaline, cytoplasm without droplets when young, but forming granular contents that primarily congregate at the poles when mature, slightly ornamented with low warts, 15-20 x 8.5-10.5 µm, aseptate. *Paraphyses* with slightly

clavate tips (Fig. 2.38), mostly 3-septate, most slightly higher than asci although some lower, 3-5 µm wide.

Material accessioned: CANADA: Alberta: Near Elk Island National Park: *Typha latifolia* leaves (MJS-13/ALTA 13108), Beaverhill Bird Observatory, near Tofield (MJS-12/ALTA 13109).

Notes: Collected June 27 and September 27, 2001 from *T. latifolia* in Site 2, a large *T. latifolia*-dominated marsh with no open water (53°39'80"N, 112°51'80"W). Identified by Donald Pfister and Karen Hansen using Kimbrough et al. (1969). Also collected at Beaverhill Bird Observatory near Tofield, Alberta. Reported from dung, decaying vegetation, and soil (Kimbrough et al. 1969). Cosmopolitan. First record from *Typha* spp.

Leptospora rubella (Persoon:Fries) Rabenhorst, 1857, Herbarium Mycologicum Ed. II n. 532 Figs 2.40-2.43

(Pleosporaceae, Dothideales)

Perithecia ampulliform with a 200-250-µm-long neck with an apical ostiole (Fig. 2.40), exterior of textura globosa, often with small white hairs approximately 3 µm wide, overall 450-500 µm long x 250-320 µm wide, black. *Asci* 8-spored, filiform (Fig 2.41*a, c-d*), equal to slightly tapering downwards, (100) 126-146 x (2.5) 3.5-5 µm, spores tightly coiled when young becoming loosened in age (Fig. 2.42), thick-walled when young (Fig 2.41*d*). *Ascospores* filiform (Fig. 2.43), hyaline, smooth, (113) 135-150 x 1.3-2.0 µm, multiseptate with each cell 6.5-7 µm long. *Pseudoparaphyses* filiform with tips clavate to subulate (Fig. 2.41*b*), hyaline, multiseptate, approximately 140-187 x 1.2 µm, with short lateral branches.

Material accessioned: CANADA: Alberta: Elk Island National Park: *Typha latifolia* leaves (MJS-14/ALTA 13110).

Notes: Collected June 27, 2001 near base of *T. latifolia* plant at Site 2, a large *T. latifolia*-dominated marsh with no open water (53°39'80"N, 112°51'80"W). Identified using Brietenbach and Kränzlin (1981) and Walker (1980). Reported from many plants in temperate regions (Farr et al. 2002). First record from *Typha* spp.

Massariosphaeria typhicola (Karsten) Leuchtmann, 1984 (1985), Sydowia 37: 168

Figs 2.44-2.46

(Lophiostomataceae, Dothideales)

Perithecia globose with a short neck (Fig. 2.44), 200-290 µm diameter, black. *Asci* 8-spored, obovoid (Fig. 2.45), (68) 70.5-85 (92) x (11.5) 12-13 µm, thick-walled when young. *Ascospores* triseriate (Fig. 2.45), navicular (Fig. 2.46), straight or slightly curved, dark amber, immature smooth (Fig. 2.46*a*), mature echinulate (Fig. 2.46*b*), (30) 32-41 (44) x 6.5-8 (9) µm, 8-9-septate with 4th or 5th cell enlarged, septations +/- constricted, with gelatinous sheath at least when young (Fig. 2.46*a*), with remnants sometimes attached to released spores (Fig. 2.46*b*), germ tubes emerge from one or both terminal cells. *Colony* on MEA olivaceous, darker towards the middle, thick floccose, reverse black with similar pattern, 31 mm diameter at 10 days, produced perithecia after incubation on sterilized *T. latifolia* leaf. Cellulolytic, utilizes starch and tannic acid.

Material accessioned: CANADA: Alberta: Elk Island National Park: *T. latifolia* leaves (MS-8/DAOM 231301/UAMH 10283, MJS-27/ALTA 13111).

Notes: Collected September 27, 2001 at the bases of *T. latifolia* plants at Site 3, a small temporary lake with *T. latifolia* forming a thin (<1 m wide), patchy border along with water arum (*C. palustris*) and sedges (*Carex* sp.) (53°41'50"N, 112°48'60"W). Identified using Shoemaker and Babcock (1989). Reported from numerous wetland monocots in Canada and Europe (Shoemaker and Babcock 1989, Leuchtmann 1984, Eriksson 1992).

***Mollisia* sp.** Figs 2.47-2.49

(Dermateaceae, Leotiales)

Apothecia clustered to scattered, sessile (Fig. 2.47), globose when young, becoming cupulate, then flat to convex with margin irregular in larger ascomata, smooth, 0.3-1.3 mm diameter, gray turning black in age and when dried. *Asci* 8-spored, clavate (Fig. 2.48), 46-65 x 4-6 µm. *Ascospores* uniseriate (Fig. 2.48), fusiform (Fig. 2.49), hyaline, smooth, 5-15 x 1.5-2.5 µm, aseptate, length varying between individuals.

Material accessioned: CANADA: Alberta: Elk Island National Park: *Typha latifolia* leaves (MJS-15/ALTA 13112, MJS-16/ALTA 13113, MJS-16/ALTA 13114).

Notes: Common on lower portions of *T. latifolia* plants on June 27 and September 27, 2001 at Sites 1 (a small pond surrounded by a wide (approximately 4-6 m) border of *T. latifolia* (53°42'35"N, 112°52'00"W)), 2 (a large *T. latifolia*-dominated marsh with no open water (53°39'80"N, 112°51'80"W)), and 3 (a small temporary lake with *T. latifolia* forming a thin (<1 m wide), patchy border along with water arum (*C. palustris*) and sedges (*Carex* sp.) (53°41'50"N, 112°48'60"W)).

Mycosphaerella recutita (Fries: Fries) Johanson, 1884, Öfversigt af Kungliga Vetenskapsakademiens Förhandlinger 41: 166 Figs 2.50-2.52

(Mycosphaerellaceae, Dothideales)

Perithecia immersed (Fig. 2.50), globose, (35) 42.5-57.5 (72.5) µm, black. *Asci* 8-spored, obovoid with the tip constricting in age (Fig. 2.51), 21-28 x 8-10 µm, approximately 15 per ascocarp, young asci thick-walled. *Ascospores* bi- to tri-seriate (Fig. 2.51), fusiform (Fig. 2.52), hyaline, 12-13.5 x 3-4 µm, 1-septate, slightly constricted at the septum.

Material accessioned: CANADA: Alberta: Elk Island National Park: *Typha latifolia* leaves (MJS-18/ALTA 13115)

Notes: Collected June 27, 2002 from *T. latifolia* leaves in EINP. Identified using von Arx (1949). These specimens differ in having a slightly constricted septum, and slightly thinner asci (10-14 µm in von Arx, 1949). Reported from many monocots in North America and Northern Europe (Farr et al. 2002). First record from *Typha* spp.

Phaeosphaeria typhae (Karsten) Shoemaker and Babcock, 1989, Canadian Journal of Botany 67: 1536 Figs 2.53-2.54

(Phaeosphaeriaceae, Dothideales)

Perithecia immersed, globose with a short beak, approximately 133 µm diameter, black. *Asci* 8-spored, cylindrical to slightly clavate (Fig. 2.53), 42-65 x 9-11 µm, young asci thick-walled. *Ascospores* biseriate (Fig. 2.53), narrowly fusiform (Fig. 2.54), isodiametric, straight or slightly curved, yellowish brown, smooth, (16.5) 19-22 x 4-5 (7) µm, 3-septate, constricted at middle septum, occasionally at others. *Paraphyses* equal (Fig. 2.53), multiseptate, shorter than asci, 1.2-2.5 µm wide,

approximately 4/ascus in vertical cross-section. *Colony* on CMA light olivaceous, with little aerial mycelium. Gelatinolytic, cellulolytic, lignolytic, utilizes starch and tannic acid.

Material accessioned: CANADA: Alberta: Elk Island National Park: *T. latifolia* leaves (MS-5/DAOM 231302/UAMH 10284).

Notes: Collected June 27, 2001 from old *T. latifolia* leaves in EINP. Identified using Shoemaker and Babcock (1989). Reported from *T. latifolia* in Germany (Shoemaker and Babcock 1989). First record outside of Germany.

Podospora* cf. *glutinans (Cain) Cain, 1962, Canadian Journal of Botany 40: 460

Figs 2.55-2.61

(Lasiosphaeriaceae, Sordariales)

Colony on CMA yellow-brown, faintly zonate, aerial mycelium sparse and mostly associated with perithecia, 20 mm diameter at 7 days, perithecia abundant, particularly in center 3 cm, also producing anamorph (see below). *Perithecia* superficial (Fig. 2.55), ovoid with a straight, or more commonly curved, beak with a central ostiole, wall highly ornamented, 520-900 x 250-400 µm, l/w 1.9-2.3, black. Wall multi-layered (Fig. 2.56), consisting of elongate cells in interior graduating into globose cells on exterior, about 8 cells wide but thinning considerably towards the base. Ornamentations consisting of numerous 4-sided pyramidal protrusions constructed from numerous, globose to irregularly-shaped 4-10 µm diameter cells, generally with 3 or more exterior cells giving rise to smooth, hyaline hyphae that extend to agar surface, adjacent perithecia, or become short hairs, the latter particularly in apical region. Beak lined with smooth, hyaline periphyses that are 7-14 x 2-2.5 µm. *Asci* 8-spored, cylindrical (Fig. 2.57*a*), (250) 265-325 x (25) 28-36 µm, about 10 in perithecial long-section, with an apical ring (Fig. 2.57*b*) and long filiform base. *Ascospores* uniseriate (Fig. 2.57*a*), each with a black head cell and a hyaline pedicel cell (Fig. 2.58), with long gelatinous appendages from both apices, smooth. Septation between cells occurs early in development. *Head cell* oval to slightly lemoniform, with a central or slightly eccentric germ pore at end opposite pedicel, 29-36 x 16-21 µm. *Pedicel* straight or slightly curved, 6-14 x 2 µm. *Appendages* filiform, hyaline, approximately 2 µm wide and thinning to <0.5 µm toward distal end, to 190

µm long but often breaking or becoming crushed. *Paraphyses* hyaline, smooth, about the same height as asci, of 3 or more oval to fusiform cells gradually decreasing in size towards the tip (Fig. 2.59), highly constricted at the septa, forming 3-4 µm wide necks between cells. Basal cells approximately 80 x 26 µm, middle cells approximately 40 x 20 µm, tip cells 25-38 x 10-15 µm. Cellulolytic.

Anamorph: ***Cladorrhinum* sp.** *Phialides* consisting of 2-3 µm wide by 1.5-2 µm high collarettes that are intercalary (Fig. 2.60*a*), terminal (Fig. 2.60*b*), or on 7-12 x 4 µm smooth, hyaline, *Phialophora*-like phialides (Fig. 2.60*c*), all generally at about a 45-60° angle from hyphae. *Conidia* sparse, globose to subglobose (Fig. 2.61), hyaline, smooth, 2-3 µm diameter.

Material accessioned: None

Notes: Isolated from ascocarp of *Mollisia* sp. growing on *T. latifolia* in EINP. Differs from *P. glutinans* by having superficial perithecia, producing perithecia when grown on CMA, having larger (250) 265-325 x (25) 28-36 µm asci, and having a *Cladorrhinum* anamorph. *Podospora glutinans* perithecia are partially to almost fully immersed (Bell and Mahoney 1995) or have their bases immersed (Mirza and Cain 1969), do not produce perithecia on CMA (Bell and Mahoney 1995), have smaller 190-220 x 24-28 µm asci (Mirza and Cain 1969), and have a *Phialophora* anamorph (Bell and Mahoney 1995). This fungus is likely a new species (J. Krug, University of Toronto, pers. comm.).

Rivilata ius Kohlmeyer, 1998, *in* Kohlmeyer et al., Canadian Journal of Botany 76: 472 Figs 2.62-2.64

(Saccardiaceae, Dothideales)

Perithecia erumpent through host cuticle at maturity, to 250 µm diameter, black. *Asci* 8-spored, bluntly clavate (Figs 2.62-2.63), 28-37 x 12-15 µm, only 4-6 per perithecium, with thick walls when young (Fig. 2.63). *Ascospores* irregularly arranged in ascus (Figs 2.62-2.63), oblong (Fig. 2.64), hyaline, guttulate, smooth, 1-septate, constricted at septum, with upper cell larger and with a slightly pointed apex, and lower cell with apices rounded or slightly truncate. *Colony* on MEA black, margin irregular, slow-growing, forming black hyphal clusters on sterilized *T. latifolia* leaves.

Produced sporocarps on OA with cellophane film (Lynne Sigler, pers. comm.). Gelatinolytic, cellulolytic, lignolytic, utilizes starch and tannic acid.
Material examined: CANADA: Alberta: Elk Island National Park: *T. latifolia* leaves (MS-20/UAMH 10285). **USA: North Carolina:** Atlantic Coast: Dead standing leaves of *J. romerianus* (UME J.K. 5590).

Notes: Collected June 27, 2001 from EINP, in folded, dead standing leaves of *T. latifolia*. Although only two ascomata were found, the distinctive subcuticular growth, habitat on long-dead monocot leaves in wetlands, and ascospore shape leave little doubt. Identified using Kohlmeyer et al. (1998). My specimens differ in having slightly thinner asci (19-23 µm in Kohlmeyer et al. (1998)). Reported from *Juncus roemerianus* Schelle in North Carolina (Kohlmeyer et al. 1998). First record from *Typha* spp. and outside North Carolina.

Scutellinia heterosculpturata Kullman and Raitviir, 1977, Folia Cryptogamica Estonica 7:4 Figs 2.65-2.68

(Otideacae, Pezizales)

Apothecia cupulate, gregarious, light orange to red, with excipulum covered in black hairs. *Hairs* straight (Fig. 2.65), widening in middle, pointed, blackish-brown, thick-walled, stiff, brittle, septate, 260-460 x 20-29 µm, irregularly branching at base (Fig. 2.66). *Asci* 8-spored, slightly clavate, 228-292 x 14-19 µm. *Ascospores* uniseriate, ellipsoidal (Fig. 2.67), brown, with one or two large guttules, outer surface ornamented with two types of warts; large (up to 3 µm diameter and 1.5 µm high) and small (down to 0.5 µm diameter), also sometimes forming short ridges, 19-21 (23) x 12-14 (14.5) µm. *Paraphyses* clavate, non-septate, smooth, wrinkled, taller than asci, 4.5-7 µm at widest. *Colony* on MEA white with scattered pinkish to reddish areas, with thick, floccose aerial mycelium, 71 mm diameter after 7d. Forming chlamydospores in older cultures. *Chlamydospores* globose to subglobose or pedicellate (Fig. 2.68), ochraceous, smooth, thick-walled, intercalary or terminal, in long chains, 10-11.5 µm diameter. Gelatinolytic, cellulolytic, utilizes tannic acid.
Material accessioned: CANADA: Alberta: Elk Island National Park: *T. latifolia* leaves (MS-22/UAMH 10286).

Notes: Collected June 27, 2001 from Sites 1 (a small pond surrounded by a wide (approximately 4-6 m) border of *T. latifolia* (53°42'35"N, 112°52'00"W)) and 2 (a large *T. latifolia*-dominated marsh with no open water (53°39'80"N, 112°51'80"W)), near bases of standing-dead plants. Identified using Schumacher (1990). My specimens differ in being slightly smaller (1-4 mm versus 3-15 mm) with thinner paraphyses (4.5-7 µm versus 6-14 µm), but match otherwise in ascospore size and morphology, hair morphology, and habitat. Reported from humus and debris in swampy areas among marsh plants in the former USSR, Norway, Iceland (Schumacher 1990), and perhaps Canada (Huhtinen 1985), although this identification is doubtful (Schumacher 1990). First record from *Typha* spp.

Talaromyces ohiensis Pitt, 1979, The genus *Penicillium* and its teleomorphic states *Eupenicillium* and *Talaromyces* p. 502 Figs 2.69-2.73

(Trichocomaceae, Eurotiales)

Colony on MEA white and floccose with bright yellow cleistothecia and scattered conidiophores, attaining 35 mm diameter at 2 weeks at 25°C, and 1 mm at 40°C (only a few conidiophores observed on natural substrate). *Cleistothecia* bright yellow, superficial, globose (Fig. 2.69), peridium of loosely woven yellow hyphae (many encrusted with yellow granules), (350) 460-535 µm diameter when mature. *Asci* 8-spored, globose to subglobose (Fig. 2.70), in chains, 5.5-8.5 x 7-9 µm. *Ascospores* hyaline, ellipsoidal (Fig. 2.71), with thin, irregular ridges of variable length, 3-4 x 2.2-3 µm. My isolate produces glauconic acid (Frisvad, pers. comm.), which is characteristic of *T. ohiense* (Frisvad et al 1990). Gelatinolytic, cellulolytic, utilizes starch.

Anamorph: ***Penicillium ohiense*** Huang and Schmitt, 1975, Ohio Journal of Science 75: 78

Phialides produced solitarily (Fig. 2.72), or in monoverticillate and occasionally biverticillate heads, in whorls of 3. *Conidia* subglobose to ovoid (Fig. 2.73), hyaline, smooth, 1.5-3 x 1.2-2.5 µm.

Material accessioned: CANADA: Alberta: Elk Island National Park: *T. latifolia* leaves (MS-6/UAMH 10287).

Notes: Isolated from surface-sterilized *T. latifolia* leaves in moist chambers. Leaves collected June 27, 2001 from Site 2, a large *T. latifolia*-dominated marsh with no open water (53°39'80"N, 112°51'80"W), from outer leaves at plant base. Identified by Jens Frisvad, BioCentrum-DTU, Technical University of Denmark using Pitt (1979) and Frisvad et al. (1990). Reported from soil in Japan and Ohio (Huang and Schmitt 1975). First record from leaves and in Canada.

***Tapesia* sp.** Figs 2.74-2.79

(Dermateaceae, Leotiales)

Apothecia short-stipitate when young (Fig. 2.74), sessile when old, shallowly cupulate, margin smooth, slightly papillose on outer sides (Fig. 2.75), 0.3-0.8 mm diameter, white. *Asci* 8-spored, (Fig. 2.76), (35) 40-45 x 3-4.5 µm. *Ascospores* uni- to bi-seriate (Fig. 2.76), oblong (Fig. 2.77), sometimes slightly curved, hyaline, guttulate, smooth, 4-7 x 1-1.5 (1.7) µm, sometimes with gelatinous substance attached. *Paraphyses* equal with slightly pointed clavate tips (Fig. 2.76), to 2-septate, +/- same height as asci. *Colony* on CMA white, thin, with minimal aerial mycelium, older with purple center, 21 mm at 10 days at room temperature. Producing anamorph. Gelatinolytic, cellulolytic, lignolytic, utilizes starch and tannic acid. *Anamorph acremonium*-like, with conidia formed blastically from short conidiophores or more rarely from papillae on the sides of hyphae (Fig. 2.78). *Conidiogenous hyphae* hyaline, staining poorly, with few visible septations. *Conidia* produced singly or in slimy heads, fusiform to slightly curved or irregularly shaped (Fig. 2.79), hyaline, usually guttulate, smooth, 5-9 x 1.2-1.8 µm, aseptate.

Material accessioned: None

Notes: Collected September 27, 2002 from Sites 1 (a small pond surrounded by a wide (approximately 4-6 m) border of *T. latifolia* (53°42'35"N, 112°52'00"W)) and 3 (a small temporary lake with *T. latifolia* forming a thin (<1 m wide), patchy border along with water arum (*C. palustris*) and sedges (*Carex* sp.) (53°41'50"N, 112°48'60"W). Found at bases of *T. latifolia* plants.

2.5.3 Mitosporic fungi – Hyphomycetes

***Acremonium* sp.** Figs 2.80-2.81

Mitosporic fungus (Hyphomycetes)

Colony on CMA white, with minimal aerial mycelium. *Phialides* hyaline, smooth, 20-28 x 2.0-3.0 µm with a small 1.2-1.8 µm wide x 1.0-1.8 µm long collarette (Fig. 2.80). *Conidia* ellipsoidal (Fig. 2.81), hyaline, occasionally with small guttules, smooth, 6-13.5 x 2.5-4 µm, 0-1 septate, often proliferating sympodially before and after detachment (Figs 2.80-2.81). Chlamydospores absent. Forms appressoria-like hyphae on slide cultures on CER. Gelatinolylic, cellulolytic, utilizes starch, lignin, and tannic acid.

Material accessioned: CANADA: Alberta: Elk Island National Park: *T. latifolia* leaves (UAMH 10078).

Notes: Isolated from surface-sterilized *T. latifolia* leaves in moist chambers. Leaves collected June 27, 2001, from Sites 1 (a small pond surrounded by a wide (approximately 4-6 m) border of *T. latifolia* (53°42'35"N, 112°52'00"W)) and 3 (a small temporary lake with *T. latifolia* forming a thin (<1 m wide), patchy border along with water arum (*C. palustris*) and sedges (*Carex* sp.) (53°41'50"N, 112°48'60"W). Isolated from material 0 and 38 cm from the base, from leaves in the second and third sheathing layers, in both live and standing-dead plants. This may represent a new species (L. Sigler, pers. comm.).

Arthrobotrys suberba Corda, 1839, Pracht-Flora Europäischer Schimmelbildungen p. 43 Figs 2.82-2.84

Mitosporic fungus (Hyphomycetes)

Colony on MEA white, producing abundant conidiophores. *Conidiophores* erect (Fig. 2.82), with sympodial proliferation (Fig. 2.83), 230-443 µm long. *Conidia* 1-, rarely 2-septate (Fig. 2.84), 15-30 x 6.5-12.5 µm, l/w 1.9-3, slightly constricted at septa, 1-septate spores obovoidal to ellipsoidal, 2-septate spores widely football-shaped and the result of conidia acropetally producing other conidia (Fig 2.82).

Material accessioned: CANADA: Alberta: Elk Island National Park: *T. latifolia* leaves (MS-27/UAMH 10288).

Notes: Collected September 27, 2001 from Site 1, a small pond surrounded by a wide (approximately 4-6 m) border of *T. latifolia* (53°42'35"N, 112°52'00"W), at the base

of *T. latifolia* plant. Identified by Lynne Sigler, University of Alberta Microfungus Collection and Herbarium. My culture differs in producing shorter conidiophores (to 443 µm as opposed to up to 850 µm in van Oorschot (1985)) and having some 2-septate, football-shaped spores. Recorded from soil and plant material (Farr et al. 2002). Cosmopolitan. First record from *Typha* spp.

Periconia typhicola Mason and Ellis, 1953, Mycological Papers 56: 80

Mitosporic fungus (Hyphomycetes)

Colony on CMA white; hyphae with frequent swellings, guttulate, 2-4 µm diameter. *Conidiophores* erect, penicillate, dematiaceous, smooth, 163-263 x 5.5-7 µm. *Conidia* globose, verrucose, 6-8.5 µm diameter. *Chlamydospores* globose, (6)-10-(14) µm diameter. Gelatinolytic, cellulolytic, lignolytic, utilizes starch.

Material accessioned: CANADA: Alberta: Elk Island National Park: *T. latifolia* leaves (RAM-5/UAMH 10289).

Notes: Collected November 1999 and/or May 2000 from *T. latifolia* floating mats in a beaver pond on the eastern border of EINP (53°40'N, 112°44'W). Identified by Lynne Sigler, University of Alberta Microfungus Collection and Herbarium. Reported from *T. latifolia* and *Sparganium simplex* Huds. in Great Britain (Ellis 1976). First record outside of Great Britain.

Phialophora melinii (Nannfeldt) Conant, 1937, Mycologia 29: 598 Figs 2.85-2.86

Mitosporic fungus (Hyphomycetes)

Colony on MEA white becoming dark olivaceous-green, zonate, with thin floccose mat of aerial mycelium, 12 mm diameter at 7 days. *Phialides* variable, smooth or rarely with large warts or a gelatinous covering (Fig. 2.85), 5-20 x 1.5-2 µm, occasionally proliferating percurrently, with a 2.5-4 µm wide by 1.5-2 µm high collarette. *Conidia* in slimy droplets, ovoid to oblong (Fig. 2.86), hyaline, guttulate, smooth, 4-8 x 1.2-2 µm, swelling to 13 x 3 µm after release, often swelling more at one end than the other.

Material accessioned: CANADA: Alberta: Elk Island National Park: *T. latifolia* leaves (UAMH 10077).

Notes: Isolated from surface-sterilized *T. latifolia* leaves in moist chambers. Leaves collected June 27 and September 27, 2001 from Site 2, a large *T. latifolia*-dominated marsh with no open water (53°39'80"N, 112°51'80"W), from outer leaves 0 and 76 cm from the base, in standing-dead plants. Identified by Lynne Sigler, University of Alberta Microfungus Collection. Reported from wood and wood pulp in North temperate regions (Farr et al. 2002, Cole and Kendrick 1973). First record from leaves.

Septofusidium herbarum (Brown & Smith) Samson, 1974, Studies in Mycology 6: 87 Figs 2.87-2.88

Mitosporic fungus (Hyphomycetes)

Conidiophores hyaline, smooth or roughened, 25-45 x 2-4 µm, on long sparingly-branched flexuous hyphae (Fig. 2.87). *Conidia* in long, unbranched chains (Fig. 2.87), fusiform to oval with one or both ends truncated or with conspicuous scar (Fig. 2.88), hyaline, lightly verruculose, 8.5-11.5 x 3-4.5 µm. *Colony* on OA with white to dark yellow-brown or reddish-brown patches, floccose, forming white floccose tufts, reverse dark to light reddish-brown, not sporulating. On *T. latifolia* forming white floccose tufts of conidiophores.

Material accessioned: CANADA: Alberta: Elk Island National Park: *Typha latifolia* leaves (MJS-19/ALTA 13118)

Notes: Collected September 27, 2001 from Site 2, a large *T. latifolia*-dominated marsh with no open water (53°39'80"N, 112°51'80"W), at the base of *T. latifolia* plant. Identified using Samson (1974). My specimen differs in having colonies that do not sporulate. Recorded from various plants in Europe (Samson 1974). First record from *Typha* spp. and in North America.

2.5.4 Mitosporic fungi – Coelomycetes

***Coryne* sp.** Figs 2.89-2.91

Mitosporic fungus (Coelomycetes)

Sporodochia superficial (Fig. 2.89), sessile with convex spore mass, pinkish turning reddish when dry and with spore mass similar but lighter and orange-tinged, 500-750 µm diameter, with distinct margin. *Conidiophores* of highly-branched hyphae

terminating with phialides at variable heights (Fig. 2.90). *Phialides* with small collarette (Fig. 2.90). *Conidia* gelatinous, fusiform to bacilliform (Fig. 2.91), straight or slightly curved, hyaline, smooth, 0.8-1.3 x 3-7 (12) µm. *Colony* on CMA purple with wide white margin, 15 mm diameter at 7 days. On PCA forming individual phialides with conidia identical to sporodochia.

Material accessioned: CANADA: Alberta: Elk Island National Park: *Typha latifolia* leaves (MS-30/ALTA 13101, MS-31/ALTA 13102)

Notes: Collected September 27, 2001 from Sites 1 (a small pond surrounded by a wide (approximately 4-6 m) border of *T. latifolia* (53°42'35"N, 112°52'00"W)) and 2 (a large *T. latifolia*-dominated marsh with no open water (53°39'80"N, 112°51'80"W)), from bases of *T. latifolia* plants. Identified by Lynne Sigler, University of Alberta Microfungus Collection and Herbarium.

Hymenopsis typhae (Fuckel) Saccardo, 1886, Sylloge Fungorum 4: 745

Mitosporic fungus (Coelomycetes)

Pycnidia erumpent, black. *Conidia* fusiform, dark green (black *en masse*), smooth, (13)-14-(15) x (3)-4 µm, with small gelatinous appendages, in gelatinous masses. *Chlamydospores* globose, 10-12 µm diameter, terminal. *Colony* on PDA white, reverse green to olive, appressed, mycelium almost completely obscured by abundant pycnidial and conidial production, 38 mm diameter at 10 days. Gelatinolytic, cellulolytic, lignolytic, utilizes starch and tannic acid.

Material accessioned: CANADA: Alberta: Near Elk Island National Park: *T. latifolia* leaves (RAM-6-AS3/UAMH 10290).

Notes: Collected November 1999 and/or May 2000 from *T. latifolia* floating mats in a beaver pond on the eastern border of EINP (53°40'N, 112°44'W). Reported from *Typha* spp. in Canada and Europe (Nag 1993, Sutton 1980).

Phoma typhicola Oudemans, 1901, Nederlandsch Kruidkundig Archief, Series 3, 2: 246 Figs 2.92-2.94

Mitosporic fungus (Coelomycetes)

Pycnidia erumpent (Fig. 2.92), ampulliform to convoluted, sometimes with a short neck, 140-190 µm wide by 100-170 µm deep, black. *Conidiophores* globose to slightly oblong (Fig. 2.93), about 3.5-5 x 4-5 µm. *Conidia* subglobose to oval or irregularly shaped (Fig. 2.94), hyaline, smooth, (4) 5-6 (14) x 2-3.5 (4.5) µm, in gelatinous masses.

Material accessioned: CANADA: Alberta: Elk Island National Park: *T. latifolia* leaves (MJS-26/ALTA 13116).

Notes: Collected June 27, 2001 and Sept 27, 2001 from the upper portions (72 cm from the base) of standing-dead *T. latifolia* plants in all sites. Site 1 was a small pond surrounded by a wide (approximately 4-6 m) border of *T. latifolia* (53°42'35"N, 112°52'00"W). Site 2 was a large *T. latifolia*-dominated marsh with no open water (53°39'80"N, 112°51'80"W). Site 3 was a small temporary lake with *T. latifolia* forming a thin (<1 m wide), patchy border along with water arum (*C. palustris*) and sedges (*Carex* sp.) (53°41'50"N, 112°48'60"W). Common. Identified using Millspaugh and Nuttall (1923). Reported from *T. latifolia* in Europe and California (Farr et al. 2002, Millspaugh and Nuttall 1923). First record in Canada.

Pseudoseptoria stomaticola (Bäumler) Sutton, 1980, The Coelomycetes, p. 98

Figs 2.95-2.97

Mitosporic fungus (Coelomycetes)

Colony on CMA white, with black conidiomata and pinkish spore masses. *Conidiomata* on leaves immersed and scattered to clustered (Fig. 2.95), 60-100 µm in diameter, on CMA vary from pycnidial (when immersed) to stromatal (when superficial), generally with a single layer of black globose cells under an irregular layer of annelides. *Annelides* subglobose to ampulliform or short cylindrical (Fig. 2.96), hyaline to lightly pigmented, to 11 µm long. *Conidia* usually falcate but sometimes nearly straight (Fig. 2.97), hyaline, smooth, 11.5-20 x 2-2.7 µm, aseptate, generally with one end more strongly pointed. On OA conidia more flexuous and more commonly straight or irregular.

Material accessioned: CANADA: Alberta: Elk Island National Park: *T. latifolia* leaves (MS-24/UAMH 10292).

Notes: Collected June 27, 2001 from standing-dead *T. latifolia* leaves in EINP. Identified using Bisset (1982a) and Sutton (1980). Reported from many graminicolous plants in Europe and North America (Sutton 1980). First record from *Typha* spp.

Stagonospora vitensis Unamuno, 1929, Boletín da la Sociedad Española de Historia Natural Figs 2.98-2.99

Mitosporic fungus (Coelomycetes)

Colony on MEA patterned whitish to black, thickly floccose, reverse black, with numerous clusters of dematiaceous globose cells inseparably adhered to the bottom of the plate. Hyphae variable within colonies but consistent between isolates, hyaline to dematiaceous, smooth or with large blisters. On OA similar but with chestnut brown and rusty tinges. Sporulating after 3 months incubation on 1 gram (dry weight) *T. latifolia* leaves in moist chambers (cultures grown in a similar manner on smaller, single leaf sections failed to sporulate) and on OA with cellophane. *Pycnidia* single to in large clusters or clumps, globose, black, immersed to superficial, 130-240 (380) µm diameter. *Conidiogenous cells* formed from inner cells of pycnidia (Fig. 2.98), blastic, variable. *Conidia* fusiform (Fig. 2.99), hyaline, minutely guttulate, smooth, 17-22 (28) x 5-7 µm, 2(-3) septate, constricted at septa on leaf material, but not on OA with cellophane.

Material accessioned: CANADA: Alberta: Elk Island National Park: *T. latifolia* leaves (MS-16/UAMH 10293, MS-14/UAMH 10319).

Notes: Isolated from surface-sterilized *T. latifolia* leaves in moist chambers. Leaves collected June 27 and September 27, 2001 from all sites, from outer to central inner sheathing leaves 0 and 38 cm from the base, in standing-dead and live plants. Site 1 was a small pond surrounded by a wide (approximately 4-6 m) border of *T. latifolia* (53°42'35"N, 112°52'00"W). Site 2 was a large *T. latifolia*-dominated marsh with no open water (53°39'80"N, 112°51'80"W). Site 3 was a small temporary lake with *T. latifolia* forming a thin (<1 m wide), patchy border along with water arum (*C. palustris*) and sedges (*Carex* sp.) (53°41'50"N, 112°48'60"W). Common. Identified using Sutton (1980). Reported from plant material in the U.K., Kenya (Farr et al.

2002, Sutton 1980), and nematode eggs in Brazil (Mizobutsi et al. 1999). First record from *Typha* spp. and in North America.

Stagonospora nodorum (Berkley) Castenalli & Germano, 1975-1976 (1977), Annali. Faculta di Scienze Agrarie. Universita degli Studi di Torino 10: 69 Figs 2.100-2.101

Mitosporic fungus (Coelomycetes)

Teleomorph: *Leptosphaeria nodorum* Müller (Leptosphaeriaceae, Dothideales)

Pycnidia immersed, globose, black, 130-360 µm diameter, outer wall of textura globosa. *Conidiogenous cells* formed from inner cells of pycnidia (Fig. 2.100), variable. *Conidia* fusiform to slightly curved (Fig. 2.101), one end often with a short protuberance, minutely guttulate, hyaline, smooth, (15) 22-30 x 2-3 µm, 3- or less commonly 1-septate, equal or slightly widened at septa.

Material accessioned: CANADA: Alberta: Elk Island National Park: *Typha latifolia* leaves (MJS-22/ALTA 13121, MJS-23/ALTA 13122)

Notes: Collected June 27, 2001 from *T. latifolia* in EINP. Common. Identified using Castellani and Germano (1975) and Bisset (1982b). My specimens differ slightly in often having a short protuberance on one end of the conidia. Reported from graminicolous plants (Castellani and Germano 1975, Bisset 1982b). Cosmopolitan. First record from *Typha* spp.

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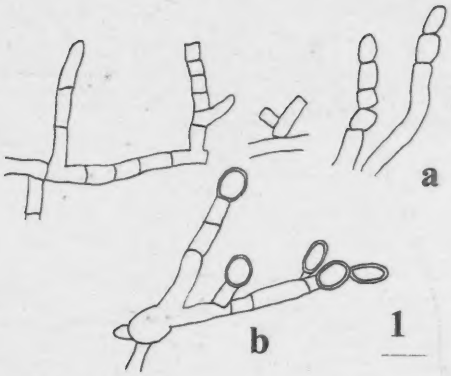
Figures 2.1-2.8. Basidiomycetes on *Typha latifolia*. **Figs 2.1-2.2.** cf. *Bjerkandera adusta* from culture on MEA. **Fig. 2.1.** Terminal schizolytic arthroconidia *(a)* and chlamydospore *(b)* production. Bar = 10 µm. **Fig. 2.2.** Guttulate arthroconidia *(a)* and chlamydospores *(b)*. Note fewer and smaller guttules in chlamydospores. Bar = 10 µm. **Figs 2.3-2.6.** *Coprinopsis radiata* from culture on OA. **Fig. 2.3.** Immature basidiocarp with abundant hairs on pileus in toothed pattern and hairs on stipe. Bar = 1 cm. **Fig 2.4.** Oval to ellipsoidal basidiospores with apiculi (top) and central germ pores (bottom). Bar = 10 µm. **Fig. 2.5.** Globose to subglobose cheilocystidia. **Fig. 2.6.** Inflated, occasionally clamped veil hyphae with constricted septa. Arrow indicates clamped septum. Bar = 50 µm. **Figs 2.7-2.8.** *Loreleia marchantiae* from material in nature. **Fig. 2.7.** Basidiocarp with umbilicate pileus, widely-spaced lamellae, and irregularly curved stipe with bumps near top. Bar = 1 mm. **Fig. 2.8.** Elliptic basidiospores. Bar = 10 µm.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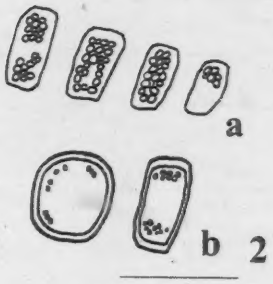
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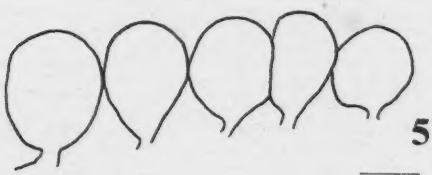
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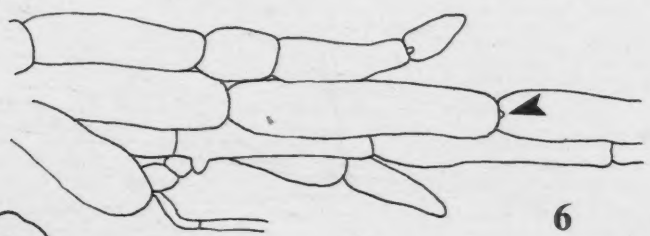
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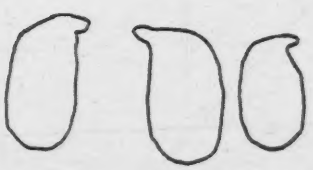
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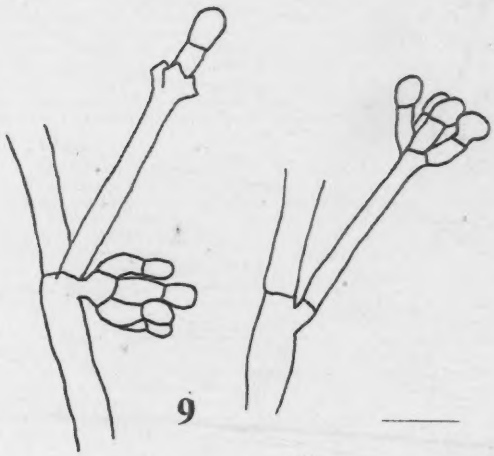
Figures 2.9-2.16. Basidiomycetes and ascomycetes on *Typha latifolia*. **Figs 2.9-2.10.** *Psathyrella typhae* arthroconidial anamorph from CMA adjusted to pH 4 and when competing with *Sclerotium hydrophilum*. **Fig. 2.9.** *Arthrographis*-like conidiophores, with 4 terminal branches consisting of 2 conidia each. Bars = 10 µm **Fig. 2.10.** Conidia. Aleuroconidia subglobose to ovoid to slightly curved with one end truncate, arthroconidia oblong-cylindrical to barrel-shaped with truncate apices at both ends. Note short neck on aleuroconidium at far right. Bar = 10 µm. **Figs 2.11-2.12.** *Sclerotium hydrophilum* on MEA. **Fig. 2.11.** Sclerotium cross-section showing dark rind and light medulla. Bar = 500 µm. **Fig. 2.12.** Hyphal structure of medulla and rind; rind with globose cells; and medulla with highly-branched inflated elongate cells. Bar = 10 µm. **Figs 2.13-2.16.** *Albotricha acutipila* from material in nature. **Fig. 2.13.** Short-stipitate apothecium with dentate margin. Bar = 100 µm. **Fig. 2.14.** Thin-walled hairs with thick septa. Note apical cell inflated and slightly pointed. Bar = 10 µm. **Fig. 2.15.** Clavate asci and septate paraphyses with equal and clavate tips. Bar = 10 µm. **Fig. 2.16.** Ascospores. Note irregular shapes. Bar = 10 µm.



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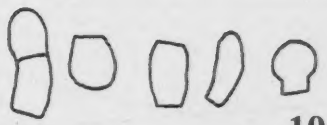

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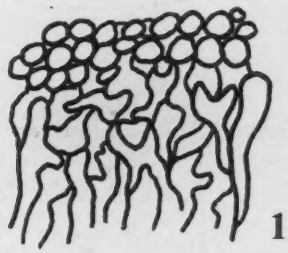

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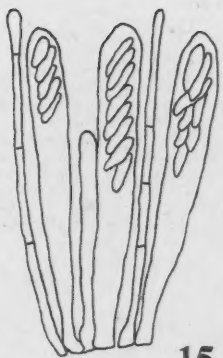

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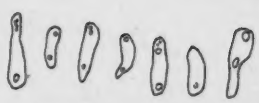

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Figures 2.17-2.28. Ascomycetes on *Typha latifolia*. All figures from material in nature. **Figs 2.17-2.20.** *Cistella* sp. **Fig. 2.17.** Sessile apothecium with marginal hairs. Bar = 100 µm. **Fig. 2.18.** Hair ornamented with warts. Bar = 5 µm. **Fig. 2.19.** Cymbiform ascus. Bar = 10 µm. **Fig. 2.20.** Irregularly fusiform, aseptate ascospores with one end more tapered than the other. Bar = 10 µm. **Figs 2.21-2.24.** *Hyaloscypha glyceriae*. **Fig. 2.21.** Sessile apothecium with marginal hairs. Bar = 100 µm. **Fig. 2.22.** Hair ornamented with spines. Bar = 10 µm. **Fig. 2.23.** Ascus with pronounced pore and paraphyses with equal or slightly clavate tips. Note triseriate arrangement of ascospores. Bar = 10 µm. **Fig. 2.24.** Fusiform to bacilliform, 0-2-septate ascospores with mostly tapered ends. Bar = 10 µm. **Figs 2.25-2.28.** cf. *Hyaloscypha glyceriae*. **Fig. 2.25.** Dried (inrolled) apothecium with warts on outer surface and dentate margin. Bar = 100 µm. **Fig. 2.26.** Hairs ornamented with spines. Bar = 10 µm. **Fig. 2.27.** Clavate 2-spored ascus with truncate tip and paraphysis with pointed tip. Bar = 10 µm. **Fig. 2.28.** Fusiform 3-septate ascospores with one guttule per cell. Bar = 10 µm.

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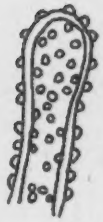

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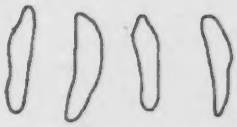

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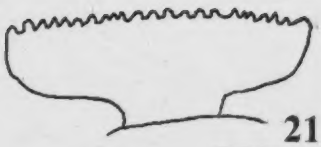

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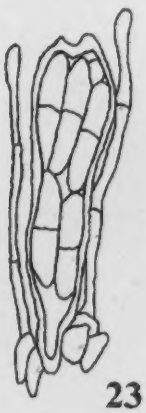

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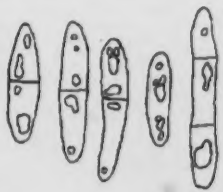

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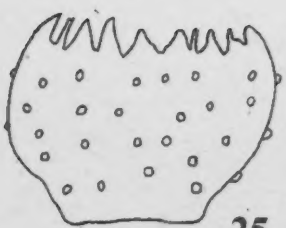

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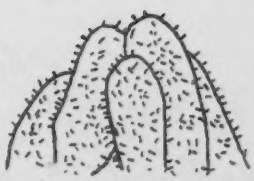

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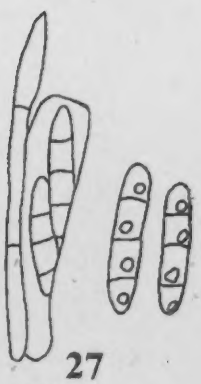

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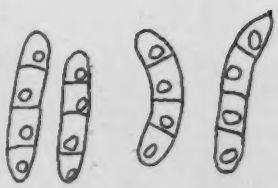

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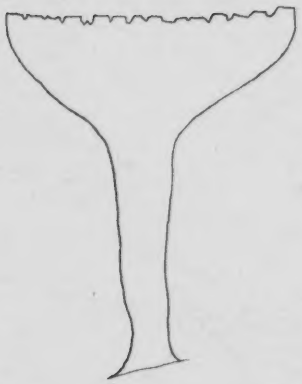
Figures 2.29-2.39. Ascomycetes on *Typha latifolia*. All figures from material in nature. **Figs 2.29-2.31.** *Hymenoscyphus repandus*. **Fig. 2.29.** Stipitate apothecium with stipe tapering towards base and rimose margin. Bar = 500 µm. **Fig. 2.30.** Clavate ascus with equal, septate paraphysis. Bar = 10 µm. **Fig. 2.31.** Irregularly cylindrical, aseptate and 1-septate ascospores. Bar = 10 µm. **Figs 2.32-2.35.** *Hymenoscyphus scutulus*. **Fig. 2.32.** Stipitate, slightly convex apothecium. Bar = 1 mm. **Fig. 2.33.** Habit on *T. latifolia* plant with long-stiped specimen growing between basal sheathing leaf layers. Bar = 5 mm. **Fig. 2.34.** Clavate ascus with equal, septate paraphyses. Bar = 50 µm. **Fig. 2.35.** Aseptate and 1-septate ascospores with pointed apices. Bar = 5 µm. **Figs 2.36-2.39.** *Iodophanus carneus*. **Fig. 2.36.** Sessile apothecium with sparse hairs. Bar = 1 mm. **Fig. 2.37.** Hairs. *(a)* Smooth, thin hairs from small apothecium. Bar = 10 µm. *(b)* thick, roughened hair from large apothecium. Bar = 50 µm. **Fig. 2.38.** Equal and slightly clavate asci and paraphyses with slightly clavate tips. Bar = 100 µm. **Fig. 2.39.** Oval ascospores with granular contents congregating at poles. Bar = 10 µm.



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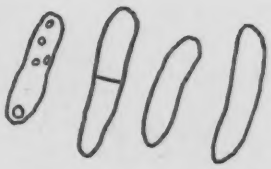

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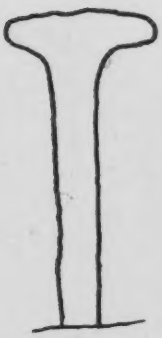

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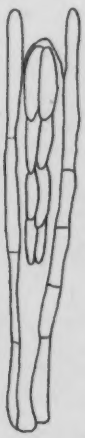

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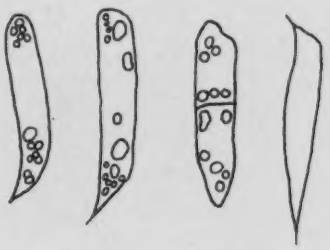

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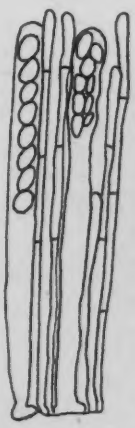

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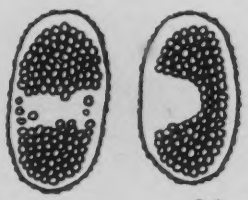

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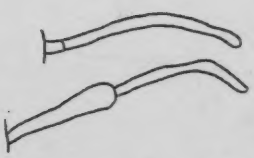

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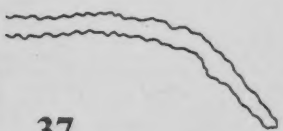

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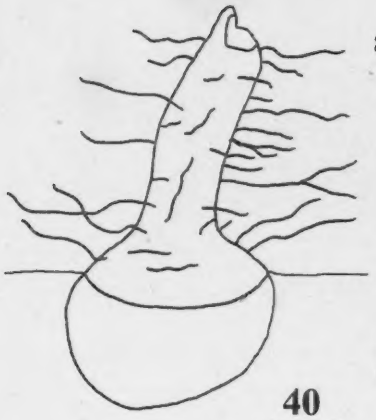
Figures 2.40-2.49. Ascomycetes on *Typha latifolia*. All figures from material in nature. **Figs 2.40-2.43.** *Leptospora rubella*. **Fig. 2.40.** Perithecium with long neck, apical ostiole, and hairs. Bar = 100 µm. **Fig. 2.41.** Filiform asci and pseudoparaphyses. *(a)* Mature ascus. *(b)* Pseudoparaphysis with short lateral branches. *(c)* Thick-walled immature asci. *(d)* Dehiscing asci with unraveling ascospores. Bar = 100 µm. **Fig. 2.42.** Mature ascus tip showing coiled arrangement of ascospores. Bar = 10 µm. **Fig. 2.43.** Filiform, multiseptate ascospores. Bar = 50 µm. **Figs 2.44-2.46.** *Massariosphaeria typhicola*. **Fig. 2.44.** Globose, short-necked perithecium. Bar = 100 µm. **Fig. 45.** Obovoid ascus with triseriate arrangement of ascospores. Bar = 50 µm. **Fig. 2.46.** Navicular, multiseptate ascospores. Bar = 10 µm. *(a)* Immature ascospore with gelatinous sheath. *(b)* Mature, echinulate ascospore with remnant of gelatinous sheath (arrow). **Figs 2.47-2.49.** *Mollisia* sp. **Fig. 2.47.** Top view of mature sessile apothecium with irregular margin. Bar = 500 µm. **Fig. 2.48.** Clavate ascus. Bar = 50 µm. **Fig. 2.49.** Fusiform ascospores. Bar = 10 µm.



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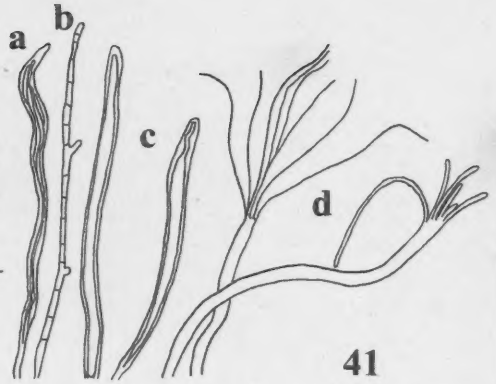

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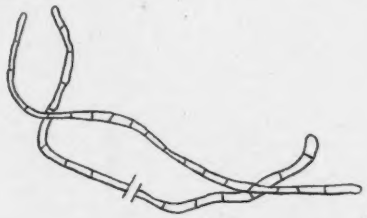

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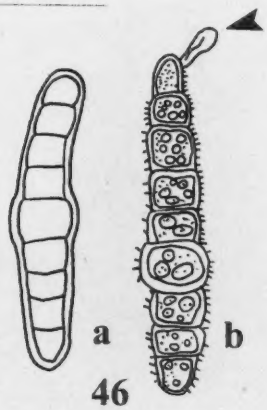

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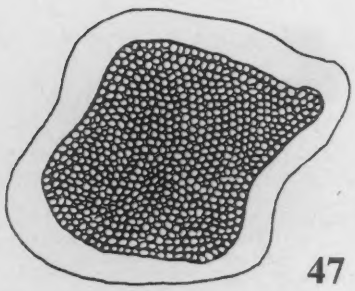

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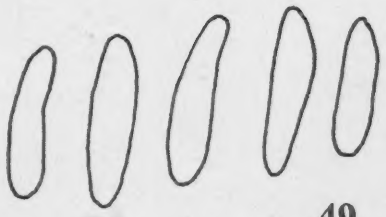

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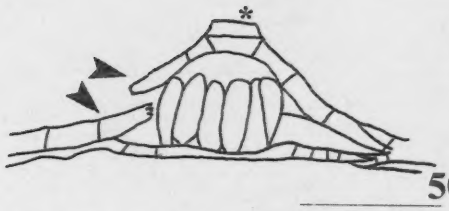
Figures 2.50-2.59. Ascomycetes on *Typha latifolia*. **Figs 2.50-2.52.** *Mycosphaerella recutita* from material in nature. **Fig. 2.50.** Section of immersed perithecium. Arrows indicate host tissue, (*) indicates position of ostiole. Bar = 50 µm. **Fig. 2.51.** Mature (left) and immature (right) obovoid asci. Note thick wall on immature ascus and constricted tip on mature ascus. Bar = 10 µm. **Fig. 2.52.** Fusiform, 1-septate ascospore; note constricted septum. Bar = 10 µm. **Figs 2.53-2.54.** *Phaeosphaeria typhae* from material in nature. **Fig. 2.53.** Cylindrical to slightly clavate asci with equal paraphyses; immature, thick-walled ascus at right. Note short, septate paraphyses. Bar = 10 µm. **Fig. 2.54.** Narrowly fusiform ascospores with constriction at central septum. Bar = 10 µm. **Figs 2.55-2.59.** *Podospora* cf. *glutinans* on CMA. **Fig. 2.55.** Long section of superficial perithecium showing beak, wall thickness and approximate orientation of asci. Bar = 100 µm. **Fig. 2.56.** Multi-layered peritheicium wall section showing graduation of cell morphologies from elongate cells in interior (left) graduating into globose cells on exterior (right). Bar = 10 µm. **Fig. 2.57.** Asci with apical ring (arrows) *(a)* Mature, cylindrical ascus. Note uniseriate arrangement of spores and long filiform base. Bar = 100 µm. *(b)* Ascus tip showing apical ring. Bar = 10 µm. **Fig. 2.58.** Ascospores with head (*) and foot (arrows) cells and long gelatinous appendages. Bar = 100 µm. **Fig. 2.59.** Paraphyses with constricted septa. Note short neck between cells and smaller cells towards tip. Bar = 100 µm.



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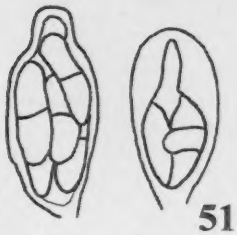

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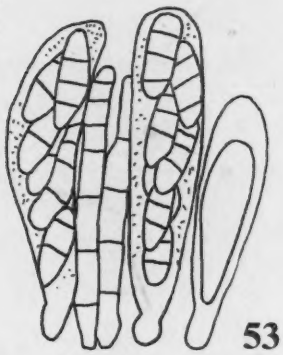

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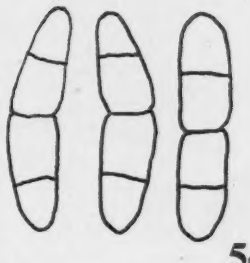

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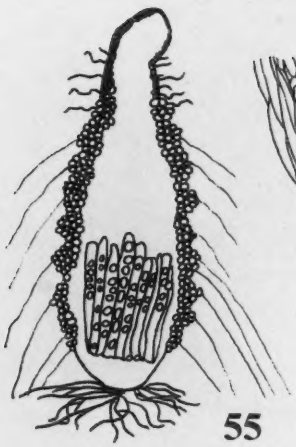

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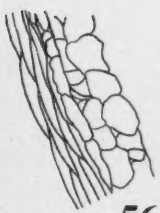

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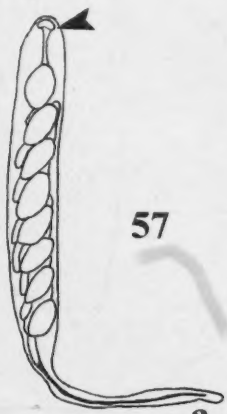

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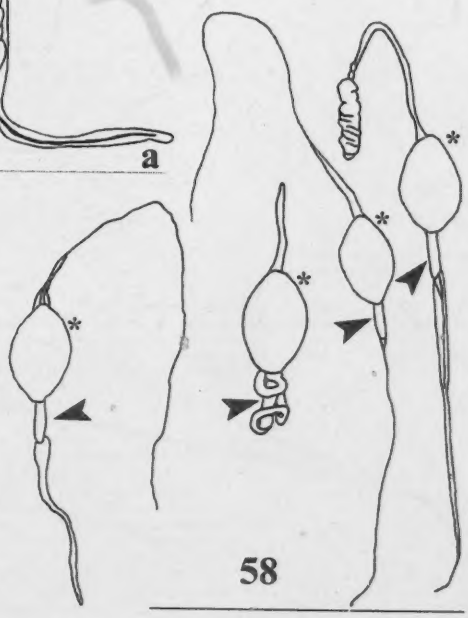

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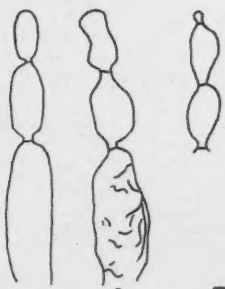

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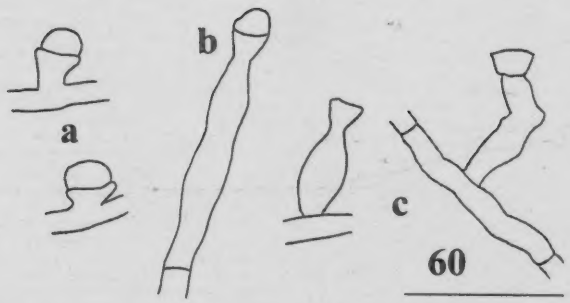
Figures 2.60-2.68. Ascomycetes on *Typha latifolia*. **Figs 2.60-2.61.** *Cladorrhinum* anamorph of *Podospora* cf. *glutinans* on CMA. **Fig. 2.60.** Phialides. *(a)* Intercalary collarettes. *(b)* Terminal collarette. *(c) Phialophora*-like phialides. Bar = 10 µm. **Fig. 2.61.** Globose to subglobose conidia. Bar = 10 µm. **Figs 2.62-2.64.** *Rivilata ius* from material in nature. **Fig. 2.62.** Mature bluntly clavate ascus. Bar = 10 µm. **Fig. 2.63.** Immature ascus with thick wall. Bar = 10 µm. **Fig. 2.64.** Oblong ascospore with constricted septum. Note that one end is pointed and the other truncate. **Figs 2.65-2.68.** *Scutellinia heterosculpturata*. From material in nature unless otherwise stated. **Fig 2.65-2.66.** Apothecial hairs. Bar = 100 µm. **Fig. 2.65.** Straight hair with thick walls and septations. **Fig. 2.66.** Irregular branching at base of hairs. **Fig. 2.67.** Ellipsoidal ascospore showing irregular sizes and patterns of warts. Bar = 10 µm. **Fig. 2.68.** Subglobose and pedicellate chlamydospores on MEA.



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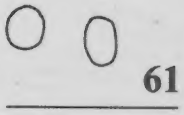

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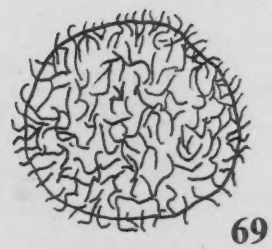

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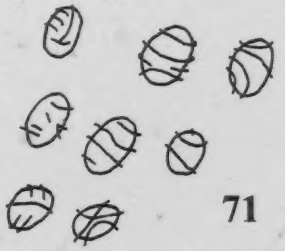

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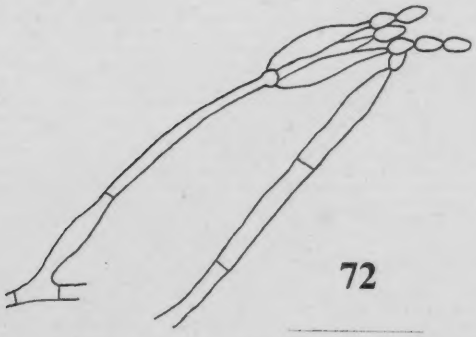

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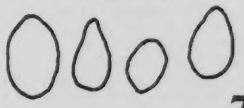

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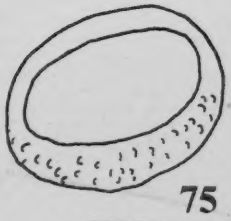

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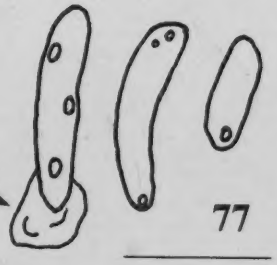

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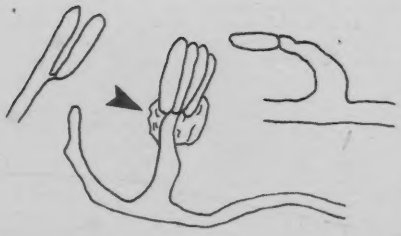

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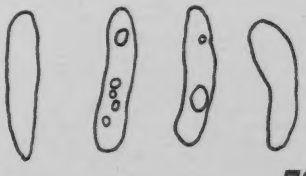

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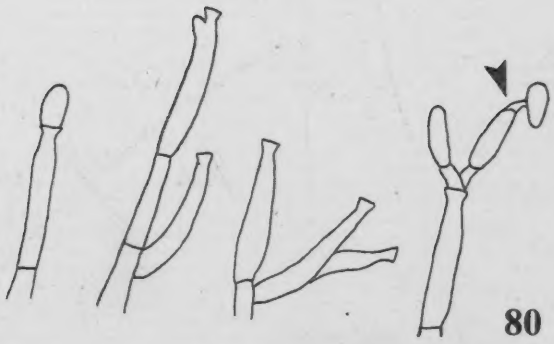
Figures 2.80-2.86. Hyphomycetes on *Typha latifolia*. **Figs 2.80-2.81.** *Acremonium* sp. on CMA. Arrows indicate conidia undergoing microcyclic conidiation. **Fig. 2.80.** Phialides. Note short collarettes. Bar = 50 µm. **Fig. 2.81.** Ellipsoidal aseptate to 1-septate conidia. Bar = 10 µm. **Figs 2.82-2.84.** *Arthrobotyris superba* on MEA. **Fig. 2.82.** Erect conidiophore. Note conidia arising acropetally from pre-existing one. Bar = 50 µm. **Fig. 2.83.** Conidiophore tip showing sympodial proliferation. Bar = 25 µm. **Fig. 2.84.** Conidia. Bar = 25 µm. **Figs 2.85-2.86.** *Phialophora melinii* on MEA. **Fig. 2.85.** Phialides. Note phialides proliferating percurrently (middle) and with large warts (right). Bar = 50 µm. **Fig. 2.86.** Ovoid to oblong conidia. Note central conidium swollen at base. Bar = 10 µm.



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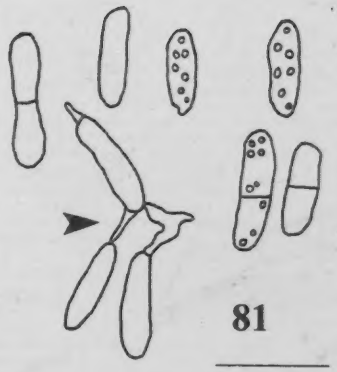

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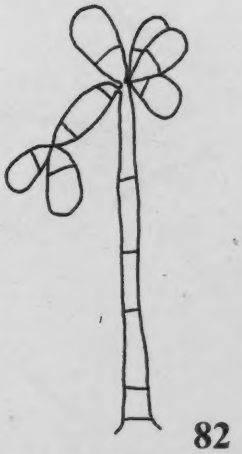

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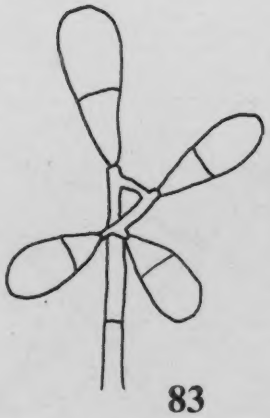

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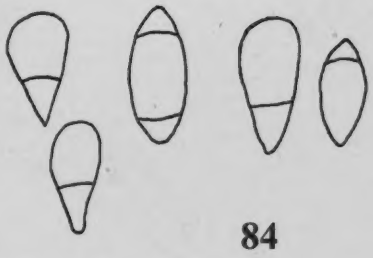

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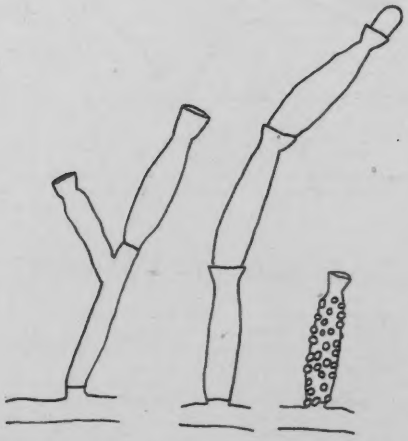

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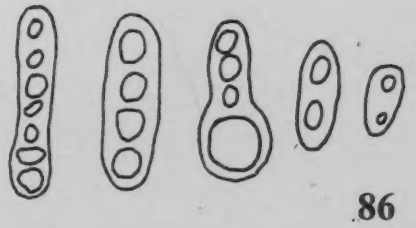

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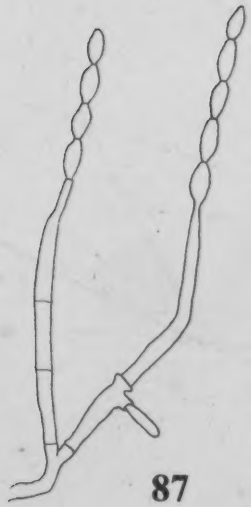
Figures 2.87-2.94. Hyphomycetes and coelomycetes on *Typha latifolia*. **Figs 2.87-2.88.** *Septofusidium herbarum* from material in nature (direct mount). **Fig. 2.87.** Conidiophores on long, sparingly-branched flexuous hyphae. Bar = 25 µm. **Fig. 2.88.** Fusiform to oval, lightly verruculose conidia with ends truncated. Bar = 10 µm. **Figs 2.89-91.** *Coryne* sp. from material in nature. **Fig. 2.89.** Superficial sporodochium with distinct margin. Bar = 500 µm. **Fig. 2.90.** Branching conidiophore with phialides at variable heights. Bar = 10 µm. **Fig. 2.91.** Fusiform to bacilliform, straight to slightly curved conidia. Bar = 10 µm. **Figs 2.92-2.94.** *Phoma typhicola* from material in nature using hand sections. **Fig. 2.92.** Erumpent ampulliform pycnidium. Arrow indicates host tissue. Bar = 100 µm. **Fig. 2.93.** Globose to slightly oblong conidiophores. Arrows indicate developing conidia. Bar = 10 µm. **Fig. 2.94.** Conidia. Note irregular shapes. Bar = 10 µm.



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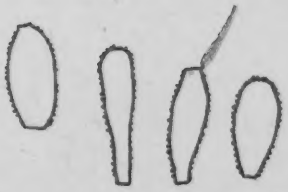

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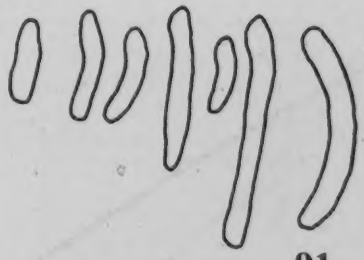

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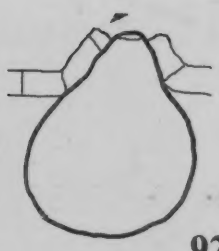

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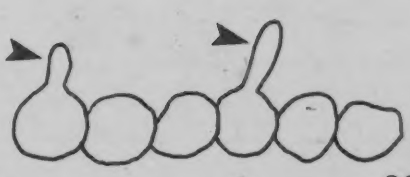

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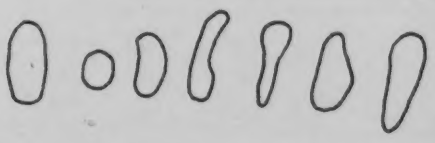

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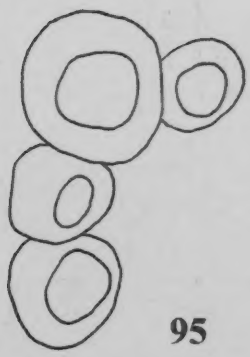
Figures 2.95-2.101. Coelomycetes on *Typha latifolia*. **Figs 2.95-2.97.** *Pseudoseptoria stomaticola*, from freezing microtome sections. **Fig. 2.95.** Top view of clustered, immersed conidiomata on material in nature. Bar = 100 µm. **Fig. 2.96.** Subglobose to ampulliform annelides on CMA. **Fig. 2.97.** Falcate to nearly straight conidia. Note that one end is generally more strongly pointed. **Figs 2.98-2.99.** *Stagonospora vitensis* from cultures inoculated on sterilized *T. latifolia* leaves after 3 months incubation in moist chambers. **Fig. 2.98.** Conidium production from wall of pycnidium. Bar = 10 µm. **Fig. 2.99.** Fusiform 2- and 3-septate conidia. Note constrictions at septa. Bar = 10 µm. **Figs 2.100-2.101.** *Stagonospora nodorum* from material in nature. **Fig. 2.100.** Conidium production from wall of pycnidium. Bar = 10 µm. **Fig. 2.101.** Fusiform to slightly curved 1- and 3- septate conidia. Note equal to slightly widened septa and short protuberance at base. Bar = 10 µm.



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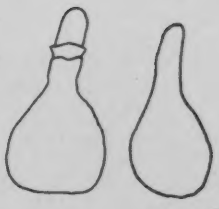

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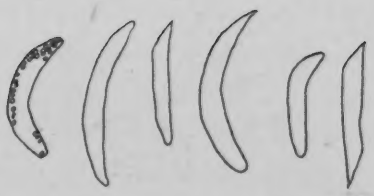

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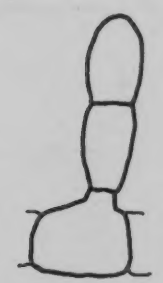

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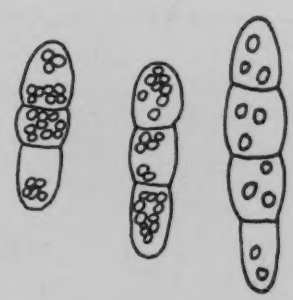

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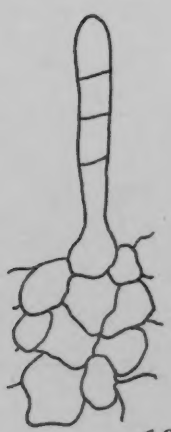

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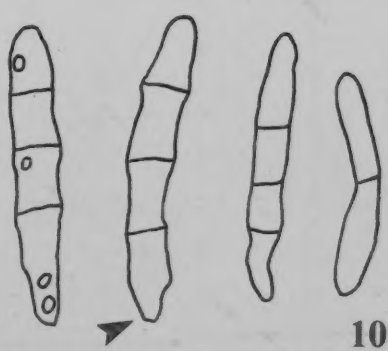

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CHAPTER 3. COMPETITIVE AND REPRODUCTIVE STRATEGIES IN TWO FUNGI THAT DECOMPOSE *TYPHA LATIFOLIA*

3.1 Introduction

Typha latifolia L., or cattail, is a major detritus producer in many wetland ecosystems. Aerial portions decay over a period of 1-2 years (Bärlocher and Biddiscombe 1996), and are predominantly decomposed by fungi (Hackney et al. 2000). During an examination of the relative contributions of different fungi to the decomposition of *T. latifolia* leaves in southern boreal wetlands, I tried to assess the extent to which competition might affect their ability to colonize and persist in these materials. From among my suite of fungal isolates I examined the interactions between two basidiomycetes, *Sclerotium hydrophilum* Saccardo apud Rothert and *Psathyrella typhae* (Kalchbr.) Pearson & Dennis, which occur in the basal sheathing leaves of senescent and decomposing *T. latifolia*. Here, *S. hydrophilum* produces minute, black sclerotia that function as asexual propagules and *P. typhae* forms small, brown mushrooms (basidiocarps). Considering that the production of basidiocarps ostensibly requires more temporal and spatial stability than the conversion of vegetative hyphae to sclerotia, I hypothesized that *P. typhae* would be the superior competitor. However, when grown together on agar media, neither fungus appeared to inhibit or interfere with the growth of the other.

The relevance of these results to understanding the potential interactions between *S. hydrophilum* and *P. typhae* in nature was suspect (Holmer and Stenlid 1993, Fravel 1988, Webber and Hedger 1986) but direct assessment of their growth together in *Typha* leaves was impractical given the difficulties associated with visualizing and measuring the growth of morphologically similar hyphae in an opaque substrate. I was thus prompted to search for an alternative method.

Here I describe how a combination of differential cultural and physiological characters was used to derive indirect measurements of the relative amounts of *Typha* leaf tissues occupied by *S. hydrophilum* and *P. typhae* when they were grown together on autoclaved leaf segments. Changes in these measurements for each

fungus over a 36-day incubation period at two different temperatures were assumed to be an accurate reflection of how these fungi fared when competing for the same resources. The results were in contrast to observations of their interactions on agar media and provided a more reliable way to test the hypothesis that different reproductive strategies in these fungi can be correlated with their competitive abilities.

3.2 Materials and methods

Pure cultures of test fungi were obtained directly from native materials. *Sclerotium hydrophilum* was isolated from surface-sterilized senescent *Typha latifolia* leaves collected in Elk Island National Park, Alberta, Canada (EINP). *Psathyrella typhae* was obtained from stipe explants from basidiocarps growing on *T. latifolia* near EINP. Cultures were stored on Corn Meal Agar (CMA, Difco) slants at 4°C and have been deposited at the University of Alberta Microfungus Collection and Herbarium (UAMH). To determine characteristics that could assist in distinguishing between the morphologically similar mycelial phases of *S. hydrophilum* and *P. typhae*, isolates of each species were grown on 14 different media. Two provided characters that clearly distinguished between *S. hydrophilum* and *P. typhae*. Both fungi grew on casamino acids media (CAS, Hutchison 1990) with *P. typhae* causing a permanent purple-to-yellow colour shift (acidification). There was no colour shift with *S. hydrophilum*. On CMA adjusted to pH 4 (with HCl) (CMA4), *S. hydrophilum* grew well and produced its characteristic minute black sclerotia. Growth of *P. typhae* on this medium was negligible.

To assess the interaction of *S. hydrophilum* and *P. typhae* in leaves at different temperatures over time, the fungi were co-inoculated on autoclaved *T. latifolia* leaf segments and incubated in moist chambers (see below) at 15 and 25°C for 9, 21, and 36 days. Controls were leaf segments inoculated with one or the other fungus. Six replicates of each treatment and each type of control were destructively harvested at each time.

A 5x1 cm *Typha* leaf segment, taken from the margin of the inner basal sheathing leaves of a living plant collected from the wild, was placed directly on a layer of 150 ml perlite moistened with 50 ml distilled water in a 100x80 mm glass storage dish. (Leaf margin segments were structurally more uniform than central areas of the blade and inner leaves had minimal fungal colonization, based on observations of leaves cleared in 10% KOH and stained with Chlorazol black E (Brundrett et al. 1994)). Leaf segments were autoclaved once when excised from the leaf and again before being inoculated in the moist chambers.

Inoculum consisted of a 3 mm diam plug taken from the growing edge of mycelium on CMA (BD) and placed at one end of a leaf segment. A plug of the other species was placed at the opposite end. Controls were inoculated at one end with either *P. typhae* or *S. hydrophilum*. Following inoculation, dishes (each containing an inoculated segment and hereafter referred to as a sample) were sealed with Parafilm and incubated. Samples were incubated simultaneously, but staggered over 4-day intervals to allow time for processing at the end of each incubation period.

At the end of the incubation periods, leaf segments from each sample were macerated individually and a representative set of particles from each was transferred to 24-well tissue culture plates (see below). Macerate was prepared by first snipping leaf segments into 1 mm wide transverse slices using sterile scissors, to reduce the length of fibers that otherwise wound around the blade of the macerator. Slices were placed in 10 ml sterile distilled water (sd-H_2O) in a 25 ml scintillation vial and ground at level "4" using a CAT Model #X-120 handheld macerator (Rose Scientific), fitted with a T10 10 mm dispersing tool, for up to 60 seconds (depending on the level of decomposition of the segment) to form a slurry of particulate fragments. The slurry was diluted with approximately 35 ml sd-H_2O in a 12.5 mm diameter plastic petri plate; particles, each with at least one vascular bundle, were rinsed with water and transferred, one per well, to all the wells of each of four 24-well tissue culture plates (Falcon®, VWR). Two plates per sample had been poured with 1 ml CAS per well, and two with 1 ml CMA4 per well. *S. hydrophilum* controls consisted of particle transfers to all the wells of two tissue culture plates containing CMA4. *P. typhae* controls were similar except transfers were to two tissue culture

plates containing CAS. Tissue culture plates were covered with parafilm to prevent hyphae from growing between adjacent wells and incubated at ambient light and temperature (approximately 20°C) in the lab.

At 10 and 20 days (for CAS and CMA4 respectively), wells with positive reactions were counted. Positive reactions were a purple-to-yellow colour shift in wells containing CAS, indicating the presence of *P. typhae*, and mycelium and sclerotia in wells containing CMA4, indicating the presence of *S. hydrophilum*. Random checks of the microscopic morphology of hyphae growing from leaf particles confirmed that the simple septate hyphae of *S. hydrophilum* were found only in wells of CMA4 showing positive reactions, and clamped hyphae characteristic of *P. typhae* were found only in wells of CAS showing positive reactions. In preliminary trials, direct microscopic examinations of hyphae on leaf samples cleared with 10% KOH and stained with Chlorazol black E showed that hyphae of each species could coexist without overt signs of mycoparasitism.

The percentage of positive wells on each type of medium and for each set of sample replicates was assumed to indicate the amount of leaf segment occupied by *S. hydrophilum* and *P. typhae*, when paired and alone, at the two different temperatures. Contaminated or accidentally missed wells were excluded from analyses. These data were analyzed with SYSTAT 8.0 (SYSTAT 1998) using Kruskal-Wallis tests to assess the effects of one species on the other, length of incubation period, and incubation temperature. Kruskal-Wallis tests were used because much of the data had no variability, and did not fit a normal distribution; thus the requirements needed for parametric analyses were not met and multifactorial tests could not be performed.

3.3 Results

In controls, at the end of the incubation period (36 days) at both 15 and 25°C, positive tests for *S. hydrophilum* had developed in 80% of the CMA4 wells and positive tests for *P. typhae* had developed in 100% of the CAS wells (Fig. 1). In paired trials at the end of the incubation period and at the same temperatures 100% of

the CAS wells tested positive for *P. typhae* and no wells of CMA4 gave a positive test for *S. hydrophilum*.

Growth in the wells was significantly lower at 15 than 25°C at 9 days ($p=0.001$) (Table 1). Significant differences due to lower growth at 15°C were also apparent in the controls ($p=0.036$) and with *P. typhae* ($p=0.005$). The total growth in the wells significantly increased over time, with differences seen overall ($p=0.019$), in the controls ($p=0.001$), with *P. typhae* ($p<0.0005$), and at 15°C ($p=0.002$). There were highly significant differences ($p<0.0005$) between the two species overall and according to all variables, except at 9 days, where the difference was not significant. There was also an overall significant difference between the paired and control groups ($p=0.003$). However, when separated by the independent variables, *S. hydrophilum* had significantly lower colonization in the paired replicates ($p<0.0005$), but there was no difference for *P. typhae*, and there was a significant difference between paired and control groups ($p=0.039$) at 25°C, but none at 15°C.

At 9 days at 15°C, *S. hydrophilum* had higher growth in the wells than *P. typhae*, in both this experiment (Fig. 1) and all preliminary trials (data not shown). This was also observed at 25°C at 5 days in preliminary trials (data not shown).

3.4 Discussion

Psathyrella typhae and *Sclerotium hydrophilum* are both basidiomycetes that inhabit the basal sheathing leaves of senescent and decomposing plants of *Typha latifolia* but display strikingly different and reproductive strategies. *P. typhae* forms fleshy ephemeral basidiocarps that release meiotic products in the form of wind-borne basidiospores while *S. hydrophilum* forms minute, deeply pigmented and presumably resistant sclerotia that also serve as lotic vegetative propagules. Many of the details concerning the life histories of these species are unknown, but I assume that the propagules of *P. typhae* (i.e. basidiospores) are produced and carried on air currents to uncolonized habitat from mid-summer to autumn while the sclerotia of *S. hydrophilum* are released from decaying substrate in the spring or throughout the

growing season and simply float to suitable new sites. *P. typhae* only forms basidiocarps on native materials and after 4 weeks incubation (Johnson et al. 1975), while *S. hydrophilum* forms abundant sclerotia on agar media within days of inoculation, indicating that the conditions required for the formation of propagules may be more exacting and/or time consuming in *P. typhae* than in *S. hydrophilum*. Thus *P. typhae* would have to grow for a greater length of time in a given habitat than *S. hydrophilum* to propagate and would be expected to be the superior competitor.

Competitive success is directly related to the ability of a fungus to occupy substrate units (e.g. Malley et al. 1996, 1994, Keddy 1989). Thus measurements of the relative growth of two fungi occupying the same material over the same period of time should indicate if competition occurs and, if so, which of them is able to occupy the greater portion of the substrate unit.

Traditionally, obtaining such measurements of the vegetative increase of fungi in natural materials has been problematic and have been limited to studies of fungi that either sporulate heavily (Adhikari and Tiwari 1991, Khan 1987) or differ significantly in cultural morphology (Widden and Hsu 1987, Widden 1984).

The technique used here allows vegetatively similar fungi to be distinguished using indicator media, and data are interpreted with the assumption that the number of counts for each species on each indicator medium is proportional to the amount of leaf occupied. Several sources of bias in these results of should be considered. First, in selecting macerated leaf segment fragments containing vascular bundles, it is possible that a fungus preferentially occupying the bundles would be favored in my experiment. However, the even distribution of vascular bundles across *Typha* leaves, the fact that other tissues were often attached to the bundles, and the consistency of the results, strongly suggest that fragment selection was not a source of bias. Second, there is a remote possibility that reactions in wells could be mis-read if both fungi were present, although random comparisons of physiological results and microscopic hyphal morphologies provided partial assurance of the validity of positive and negative scores. A third consideration is that the positive reactions for *S. hydrophilum* were obtained on inhibitive medium (i.e. low pH) and thus would lead to a negative

score if only very few viable hyphae remained in a leaf fragment. *S. hydrophilum* colonized approximately 80% of the wells at peak growth in the controls, while *P. typhae* colonized 100% (Figs. 1-2), suggesting that either approximately 20% of the *S. hydrophilum* fragments could have been false negatives, or that the colonization of leaf segments by *S. hydrophilum* was less extensive than by *P. typhae*.

Regardless, the growth of *P. typhae* in coinoculated and control leaf segments did not differ significantly indicating that *S. hydrophilum*, even though a faster growing fungus, had little or no effect on *P. typhae*. However and in marked contrast, the presence of *P. typhae* caused a dramatic decline in *S. hydrophilum* at both temperatures. Marin et al. (1998) Widden and Hsu (1987), and Widden (1984) also found that some fungal species were dominant regardless of temperature. *P. typhae* is not a known mycoparasite so this potential effect is ruled out and the effects are attributed to competitive interactions.

Although Tsuneda et al. (2001) found no discernable changes in *Sphagnum* leaf cell morphology after autoclaving, biological and chemical alterations of the *T. latifolia* leaf segments used in this study would place strong caveats on the conclusions that can be drawn about how these fungi may interact in nature. Nevertheless, based on its "ruderal" characteristics (Pugh 1980), *S. hydrophilum* is assumed to complete its life cycle relatively quickly, colonizing available substrate, extracting easily obtained nutrients, and then dispersing and/or overwintering by forming sclerotia. The life cycle of *P. typhae* is assumed to be longer in duration, enabled by its greater competitive abilities to colonize and hold on to sufficient substrate to support the formation of basidiocarps once mycelial development and environmental conditions are optimal. It may overwinter as mycelia in leaf bases, an assumption supported by its ability to grow at 4°C. Through the production of abundant and buoyant darkly pigmented sclerotia, *S. hydrophilum* may be better able to survive and establish mycelial phases during disturbances such as the periods of inundation and desiccation that are characteristic of marshlands inhabited by *T. latifolia* (Lieffers 1984).

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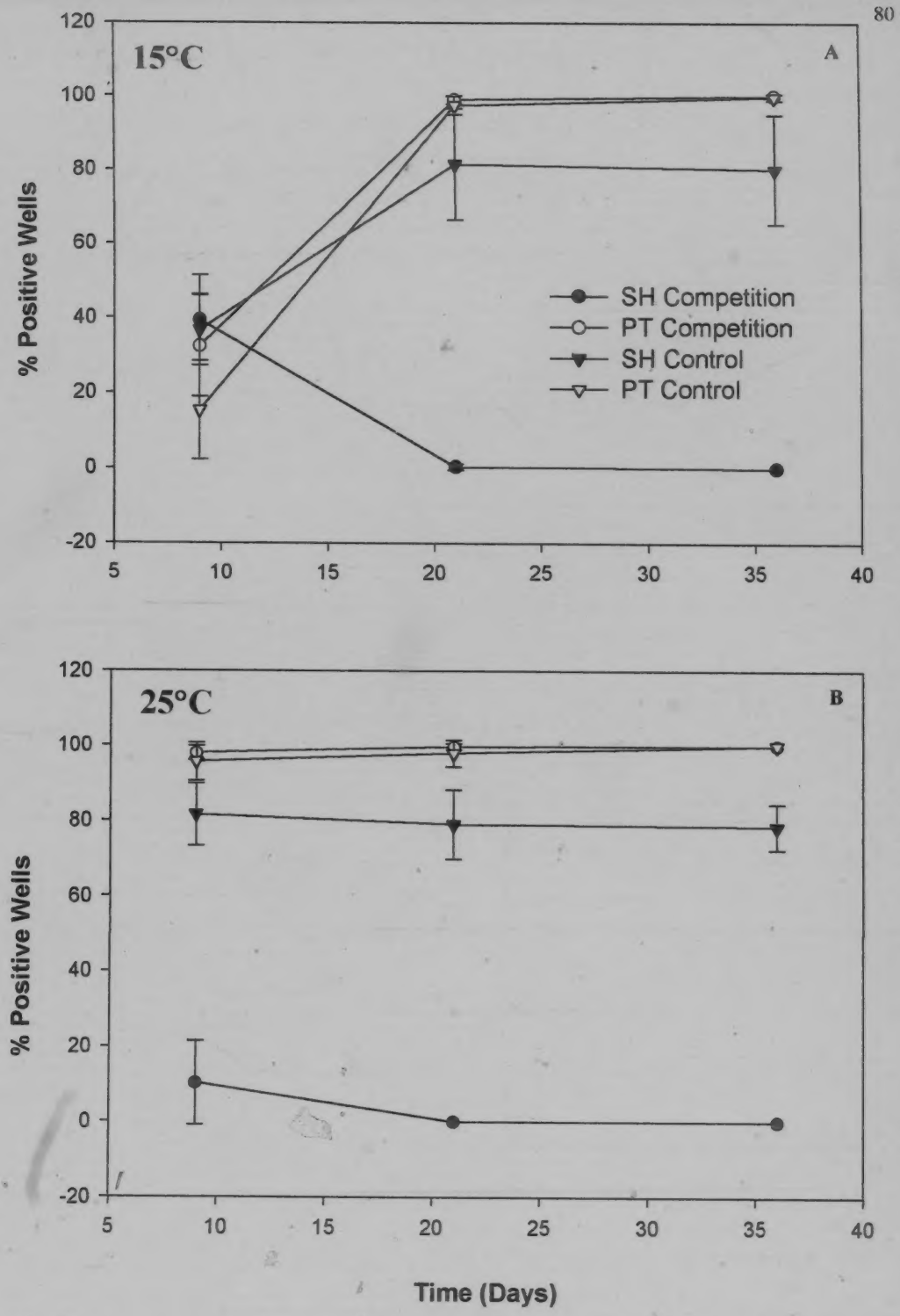
Table 3.1. Test statistics and significance according to independent variables of competition between *Psathyrella typhae* and *Sclerotium hydrophilum* using Kruskal-Wallis tests. Test statistics are the Mann-Whitney U Test Statistic or the Kruskal-Wallis Test Statistic (the latter in italics).

	Competition vs. control		Species		Temperature (°C)		Days			Overall
	Competition	Control	*P. typhae*	*S. hydrophilum*	15	25	9	21	36	
Competition vs. control	-	-	717.5^{ns}	22.50^{***}	466.0^{*}	498.0^{+}	238.5^{ns}	232.0^{ns}	222.0^{ns}	1859^{**}
Species	1269^{***}	1050^{***}	-	-	1022^{***}	1293^{***}	375.0^{+}	557.0^{***}	576.0^{***}	4643^{***}
Temperature	624.5^{ns}	464.5^{*}	425.5^{**}	636.0^{ns}	-	-	125.0^{***}	281.0^{ns}	286.0^{ns}	2159^{+}
Days	0.149^{ns}	14.76^{***}	33.39^{***}	0.672^{ns}	12.12^{**}	0.213^{ns}	-	-	-	7.936^{*}

Note: Superscripts indicate significance levels (ns = $p>0.10$, + = $p\leq0.10$, * = $p\leq0.05$, ** = $p\leq0.01$, *** = $p\leq0.001$). n=72 for Competition vs. Control, Species, and Temperature, n=48 for Days, n=144 for Overall.

Fig. 3.1. *Psathyrella typhae* (PT) and *Sclerotium hydrophilum* (SH) colonization patterns alone and in competition at 15 (A) and 25°C (B).


15°C
A
% Positive Wells
SH Competition
PT Competition
SH Control
PT Control
25°C
B
% Positive Wells
Time (Days)

CHAPTER 4: GENERAL DISCUSSION AND CONCLUSIONS

4.1 Summary of results

4.1.1. Fungi on *Typha latifolia*

Forty-one fungal species were collected and/or isolated from standing-dead *T. latifolia* leaves, including fungi traditionally found on substrates including wood, dung, leaves, and soil. An additional four species were isolated from the sporocarps of other fungi growing on *T. latifolia*. Ubiquitous fungi such as *Cladosporium herbarum* and *Aureobasidium pullulans* were found in addition to species only known from *Typha* spp., such as *Periconia typhicola* and *Phaeosphaeria typhae*. No zygomycetes or chytridiomycetes were found. Thirty-seven fungi were identified to species, and of these 24 were new published records from *Typha* spp. which, added to the 154 fungi recorded from *Typha* spp. in Farr et al. (2002), Tokumasu (1994), Redhead (1984, 1981), and Pugh and Mulder (1971), gives a new total of 178 species. Twelve fungi were new reports from Canada, of these seven were new from North America, and *Albotricha acutipila*, *Hyaloscypha glyceriae*, *Periconia typhicola*, *Phaeosphaeria typhae*, and *Rivilata ius* had never been recorded outside of their type locality.

Isolates identified as *Podospora* cf. *glutinans* and *Acremonium* sp. may represent undescribed species. In addition, anamorphic stages were reported for the first time for *Psathyrella typhae* and *A. acutipila*, and perhaps also for *P.* cf. *glutinans* and a species of *Tapesia*. The conidial production in these fungi is consistent with those of related species (*Psathyrella typhae* produces arthroconidia like other species of *Psathyrella* (see Kendrick and Watling 1979), *Tapesia* sp. and *A. acutipila* produces phialidic conidiophores like other members of the Helotiales (see Kendrick et al. 1979), and *P.* cf. *glutinans* produces a *Cladorrhinum* anamorph like *Podospora fimiseda* (Bell and Mahoney 1997)).

4.1.2. Abilities of fungi to degrade selected macromolecules and cause mass losses of *T. latifolia* leaves

Thirty-six isolates belonging to 32 species were tested for their abilities to cause mass losses of *T. latifolia* leaves and to degrade cellulose, lignin, starch, gelatin and tannic acid. The agarics *Psathyrella typhae* and *Coprinopsis radiata* and the basidiomycete *Hyphodontia sambuci* caused some of the highest mass losses (52.1

and 50.3% for the two isolates of *P. typhae*, and 45.8% and 44.6% for *C. radiata* and *H. sambuci* respectively), which is consistent with the results of Osono and Takeda (2002) who found basidiomycetes and Agaricales in particular to be the best decomposers of beech leaves. However, an unknown species of *Acremonium* caused the highest mass loss (54.6%), cf. *Hyaloscypha glyceriae* and *Thielavia terrestris* also produced high mass losses (47.5 and 44.8% respectively).

4.1.3. Competition between *Psathyrella typhae* and *Sclerotium hydrophilum*

The interactions that take place between fungi during decomposition to a large extent determine the species composition (Fredrickson and Stephanopolous 1981), which may in turn affect the decomposition process. To determine the effects of competition on fungi inhabiting *T. latifolia* leaves, I developed a technique to determine the results of interactions between the basidiomycetes *Psathyrella typhae* and *Sclerotium hydrophilum* that inhabit the basal sheathing leaves of *T. latifolia* in my study area. Because *Psathyrella typhae* was a superior decomposer *in vitro*, and produces basidiocarps that ostensibly require more spatial and temporal stability than the sclerotia produced by *S. hydophilum*, I hypothesized that *Psathyrella typhae* would be the superior competitor.

Because these fungi were morphologically similar in their vegetative state, I developed a technique that used physiological differences to distinguish between them. After growing them on a suite of indicator media and CMA adjusted to various pH's, I found that *Psathyrella typhae* produced a permanent purple-to-yellow colour change (acidification) on Casamino acid media (CAS), while *S. hydrophilum* produced no colour change, and *S. hydrophilum* grew and produced sclerotia on CMA adjusted to pH 4 (CMA4), while *Psathyrella typhae* grew poorly or not at all. I then grew the fungi together on autoclaved *T. latifolia* leaf sections and allowed them to compete at both 15 and 25°C. At 9, 21, and 36 days replicates were macerated, and the resulting particles were washed and placed, one per well, in all the wells of four 24-well tissue culture plates; two containing 1 ml CAS per well, and two with 1 ml CMA4 per well. Positive reactions (yellow colour change on CAS for *Psathyrella typhae*, and sclerotium production on CMA4 for *S. hydrophilum*) resulted from the growth of the fungi from the fragments, so the percentage of positive wells were assumed to indicate the percentage of the leaf segment occupied by the respective fungi. These results were compared to controls in which the fungi had been inoculated

singly. As hypothesized, *Psathyrella typhae* was the superior competitor, and competitively excluded *S. hydrophilum* from the leaf by 21 days at both temperatures.

4.2 Future directions

Given that I only collected material over two days, and within that time I found two species that are likely undescribed, 24 that had not been reported from *Typha* spp. previously, and 12 new to Canada, there are undoubtedly many more fungi inhabiting *T. latifolia*. It would be advantageous to investigate the ecological niches that these fungi inhabit in both space and time in more detail (i.e. determine which fungi are found at different heights on the plant or in different sheathing layers, and if they have seasonal occurrences), which could be helpful when predicting the effects environmental changes (e.g. global warming or water table changes) on fungal communities and the decomposition of *T. latifolia*. It would also be useful to determine if the enzymatic tests such as those used in this study correlate with the enzyme production of the fungi *in vivo*, perhaps by determining the concentrations of macromolecules before and after inoculation with the fungi.

My work on competition was limited by the need to develop a new technique. However, its development may allow for an expansion of work of fungal competition in leaves. It would be useful to do competition experiments between fungi with different life-history strategies under different environmental conditions (e.g. temperature, moisture levels, and with leaves at different stages of decomposition), which would give insight to the factors driving fungal succession and add further relevance to studies on fungal ecological niches. Studying the mass losses of the substrate during competition would also help to determine to what degree these interactions affect the decomposition of the substrate.

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APPENDIX 1. GLOSSARY OF MYCOLOGICAL TERMS

This glossary covers mycological terminology used in this thesis that may be unfamiliar to non-mycologists. Definitions are based on Currah (2001), Thormann (2001), and Hawksworth et al. (1995).

acervulus (-i, pl.) – saucer-shaped fructification producing mitospores.

agaric – general term for a gilled mushroom.

aleuroconidium (-ia, pl.) – a single-celled terminal conidium.

allantoid – sausage-shaped.

ampulliform – flask-shaped.

amyloid – a reaction to Melzer's reagent that gives a purplish or bluish colour, indicating the presence of starch. See also Melzer's reagent.

anamorph – a morphologically distinctive phase in the life cycle of a fungus producing asexual propagules (conidia, sclerotia, etc.).

annellide – a type of phialide which, during conidium formation, leaves a ring of wall material at the apex of the sporogenous cell; recognized by parallel rings of wall material at the phialide apex.

apiculus (-i, pl.) – a small projection at one end of a spore.

appressorium – a swelling on a germ-tube or hypha, particularly for attachment to a host during early stages of infection.

apothecium (-ia, pl.) – a cup- or disc- shaped ascoma in which the hymenium is exposed at maturity.

arthroconidia – asexual spores derived from the fragmentation of a pre-existing hypha; disarticulating at maturity.

ascocarp – see ascoma

ascoma (-ata, pl.) – an ascomycete fruiting body in or on which asci are formed.

ascospore – spore resulting from meiosis and enclosed in an ascus at maturity.

ascus (-i, pl.) – a sac-like cell in which ascospores develop after karyogamy and meiosis.

bacilliform – rod-shaped.

basidiocarp – a basidiomycetous fruiting body in or on which basidia are formed.

basidium (-ia, pl.) – a terminal cell in which karyogamy and meiosis occurs in basidiomycetes.

bitunicate – describing an ascus with two distinct wall layers.

biverticillate – having branching at two levels, *i.e.* having metulae bearing phialides.

cheilocystidium (-ia, pl.) – cystidium on the edge of a lamella.

chlamydospore – a thick-walled, asexual resting spore.

clamp connection – a buckle-shaped knob over the septum of some basidiomycetes.

clavate – club-shaped.

cleistothecium (-ia, pl.) – an ascoma with an enclosed peridium.

coelomycete – fungus producing mitospores in pycnidia, acervuli, or sporodochia.

collarette – a cup-shaped structure at the apex of a conidiogenous cell.

conidiogenous cell – a cell giving rise to conidia.

conidiophore – a structure bearing conidia and/or conidiogenous cells.

conidium (-ia, pl.) – an asexual spore (mitospore).

coprophilous (adj.) – describes organisms found principally on dung.

cupulate – cup-shaped.

cymbiform – boat-shaped.

cystidium (-ia, pl.) – a large, distinctive sterile cell found on basidiocarps of some basidiomycetes.

deliquescent – dissolving.

dematiaceous (adj.) – describing fungi with darkly-pigmented or melanized cell walls.

dentate – tooth-shaped.

discomycete – non-taxonomic term referring to ascomycetes that form apothecia.

echinulate – having sharply pointed spines.

equal (of spores or stipes) – without changes in width throughout the length.

excipulum (-a, pl.) – sterile tissue making up the outer wall of an apothecium.

falcate – shaped like the blade of a sickle.

filiform – thread-shaped.

flexuous – wavy.

floccose – cottony.

fusiform – spindle-like, narrowing towards ends.

gelatinolytic – able to degrade gelatin.

guttulate – having oil drops (guttules) in a spore.

hilum – a mark or scar, especially on a spore at the point of attachment to a conidiogenous cell or sterigma.

hyaline – transparent or colourless.

hymenium – a layer of tissue giving rise to meiospores.

hypha (-ae, pl.) – a tubular structure in which a rigid wall encloses a protoplast or series of protoplasts; extending by tip growth. The fundamental structural unit in most fungi.

hyphomycete – mitosporic fungus in which conidia are produced without pycnidia or stromata or other differentiated reproductive structures.

inoperculate – referring to an ascus that releases ascospores through a pore or slit and not an opening covered by a lid or operculum.

lamella (-ae, pl.) – vertical plate of tissue supporting the hymenium of agarics; gill.

lenticular – like a double-convex lens in form.

limoniform – lemon-shaped.

medulla – loose layer of hyphae below the rind of sclerotia or other organs, or below the cortex and algal layer in lichens.

Melzer's reagent – a solution of iodine, IKI, and chloral hydrate.

metula (-ae, pl.) – a conidiophore branch bearing phialides.

microcycle conidiation – a process in which conidium production occurs from conidial germ tubes.

monoverticillate – having only phialides at the apex of a conidiophore, without any metulae.

mycelium – a mass of hyphae.

mycoparasite – a fungus that parasitizes another fungus.

navicular – see cymbiform.

operculum – a hinged lid that permits the release of spores from asci or sporangia.

ostiole – opening in the apex of a structure (usually in reference to perithecia or

pycnidia).

paraphysis – sterile, thread-like, branched or unbranched hyphal element originating from the tissues underlying the asci and extending upward.

parasite – an organism extracting nutrients from another; may or may not cause disease.

penicillate – brush-like.

percurrent – growing through in the direction of the long axis or exending through the entire length.

periphyses – unbranched hyphae confined to the ostiolar canal of perithecial ascomycetes.

perithecium (**-ia**, pl.) – a flask-shaped ascoma with an ostiole.

phialide – a cell with a fixed conidiogenous locus at the tip through which asexual spores are extruded in basipetal series.

pileus – a cap or shelf-like structure supporting the hymenium in some basidiomycetes; cap.

pseudoparaphysis – hypha originating above the level of the asci and growing downwards between developing asci, finally becoming attached to the base of the cavity and often also free in the upper part.

pseudothecium (**-ia**, pl.) – an ascostromatic (i.e. with asci produced in a stroma) ascoma having asci in numerous unwalled locules (cavities).

pycnidium (**-ia**, pl.) – a sac-shaped structure in which conidia are formed.

pyriform – pear-shaped.

reniform – kidney-shaped.

reticulate – with a net-like pattern.

rind – the firm outer layer of a sclerotium or other organ.

saprobic – describing an organism that derives its energy from dead organisms and derivatives.

schizolytic – spore secession arising from splits between the spore and its subtending cell(s).

sclerotium (**-ia**, pl.) – perennating structure composed of mycelium and sometimes host tissue; not containing or bearing spores.

septum (**-a**, pl.) – a cross wall in a hypha.

sessile – a pileus or similar structure lacking a stipe.

sinuate – when lamellae are notched at the proximal end at the junction to the stipe.

spinose – delicately spiny; also spinulose.

sporodochium (**-ia**, pl.) – a cushion-shaped body on which mitospores are produced.

sterigma (**-ata**, pl.) – the projection on a basidium through which a basidiospore forms.

stipe – a stalk.

stroma (**-ata**, pl.) – a mass or matrix of vegetative hyphae, with or without host tissue, in or on which spores or fruit bodies bearing spores are formed.

substrate – the material(s) on which a fungus lives.

sympodial – cells undergoing continued growth after the main axis has produced a terminal spore, by the development of a succession of apices each of which originate below and to one side of the previous apex.

truncate – with an abrupt rather than rounded or blunt terminus.

umbilicate – having a shallow, discrete, rounded depression, or with a connecting cord.

verrucose – having small rounded processes or warts; also verruculose.

warted – having warty surface ornamentation.

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APPENDIX 2. FUNGI FROM *TYPHA LATIFOLIA*: COLLECTION/ISOLATION INFORMATION AND ABILITIES TO USE SELECT MACROMOLECULES AND CAUSE MASS LOSSES OF *T. LATIFOLIA* LEAVES.

This appendix summarizes the accession information and the results of enzymatic tests and mass loss determinations for fungi, as described in Chapter 2. Isolations (Isol.) are from moist chambers (MC) and/or fructifications from leaves in nature (N) or fruiting bodies of other fungi (F). Permanent slides have been accessioned at either the University of Alberta Microfungus Collection and Herbarium (UAMH) or the University of Alberta Cryptogamic Herbarium (ALTA), along with cultures (at UAMH) and/or dried specimens for fungi as indicated. Accession numbers in different columns do not correspond. "N-A" indicates isolates that have not been accessioned at the time of the publication of this thesis. Enzymatic tests include the degradation of cellulose (CEL), gelatin (GEL), starch (STA), tannic acid (TAM), and lignin (LIG). Mass losses are given as an average with the standard deviations in brackets, and "n" is the number of replicates used (note that for two isolates there are five replicates).

Fungus	Isol	ALTA	UAMH	CEL	GEL	STA	TAM	LIG	Mass loss	n
Basidiomycota										
Cf. *Bjerkandera adusta*	F	13096		1	3	0	0	0	-0.4 (3.8)	3
Coprinopsis radiata	MC	13100		3	3	2	0	3	45.8 (6.3)	3
Hyphoderma sambuci	N			3	3	1	1	3	44.6 (3.5)	3
Loreleia marchantiae	N									
Psathyrella typhae	N		10280	3	3	1	2	3	50.3 (4.3)	3
			10281	3	3	1	1	3	52.1 (0.2)	2
Sclerotium hydrophilum	MC & N	13117	10282	3	2	2	2	3	25.5 (10.8)	2
Ascomycota										
Albotricha acutipila	N		N-A	1	3	2	1	3	2.0 (1.7)	3
Cistella sp.	N	13097								
Hyaloscypha glyceriae	N	13105, 13106, 13107								
Cf. *Hyaloscypha glyceriae*	N		N-A	3	3	1	0	1	47.5 (7.4)	5
Hymenoscyphus repandus	N		N-A	0	2	1	0	0	4.8 (1.5)	2
Hymenoscyphus scutula	N		N-A	1	3	1	0	3	5.0	1
Iodophanus carneus	N	13108, 13109								
Leptospora rubella	N	13110								
Massariosphaeria typhicola	N	13111	10283	3	0	2	2	0	29.0 (2.2)	3
Mollisia sp.	N	13112, 13113, 13114								
Mycosphaerella recutita	N	13115								
Phaeosphaeria typhae	N		10284	3	2	2	1	2		
Podospora cf. *glutinans*	F		N-A	3	0	0	0	0	25.6 (7.4)	5
Rivilata ius	N		10285	1	2	1	1	1		
Scutellinia heterosculpturata	N		10286	3	3	0	3	0	12.5 (6.9)	3
Sordaria fimicola	N	13119		3	3	1	0	1	37.8 (9.8)	3

Sporormiella minima	N	13120		2	3	1	0	1	38.6 (2.2)	3
Talaromyces ohiensis	N		10287	3	1	3	0	0	18.7 (12.6)	2
Tapesia sp.	N	13123, 13124	N-A (1)	3	3	2	0	2	5.6 (1.7)	2
			N-A (2)	2	3	2	3	3	1.3 (2.6)	3
Thielavia terrestris	F		10291	3	3	2	1	3	44.8 (4.2)	3
Coelomycetes										
Hymenopsis typhae	MC & N		10290	3	3	1	3	1	21.4 (5.5)	3
Phoma typhicola	MC & N	13116								
Pseudoseptoria stomaticola	N		10292	1	0	1	2	0	3.4	1
Stagonospora vitensis	MC		10293	3	3	0	2	1	39.2 (1.5)	3
			10319	3	3	0	2	2	40.9 (4.0)	3
Stagonospora nodorum	N	13121, 13122								
Coryne sp.	N	13101								
Hyphomycetes										
Acremonium sp.	MC		10078	3	3	2	3	1	54.6 (3.1)	3
Alternaria alternata	MC									
Arthrobotyris superba	N		10288							
Aspergillus fumigatus	MC	13094		3	0	0	0	0	31.0 (12.2)	2
Aureobasidium pullulans	MC	13095		3	3	0	3	0	29.3 (22.2)	2
Cladosporium cladosporioides	MC	13098		1	3	1	3	0	2.6 (0.3)	3
Cladosporium herbarum	MC & N	13099 (1)		1	3	2	3	1	3.1 (16.0)	2
		N-A (2)		1	3	1	3	0		
Epicoccum nigrum	MC & N	13103		3	3	1	2	0	10.2 (12.6)	3
Fusarium sporotrichioides	MC	13104		3	3	3	3	1	34.5 (0.2)	3
Periconia typhicola	MC		10289	2	3	2	0	1	39.1 (15.7)	2
Phialophora melinii	MC & N		10077	3	3	0	2	0	21.7 (16.2)	2
Septofusidium herbarum	N	13118								
Verticillium lecanii	F			2	0	0	0	0	7.0	1